Vol. 49 No. 2 October 1955

Quarterly

of the

National Fire Protection Association

INTERNATIONAL

Promoting the Science and Improving the Methods of Fire Prevention and Protection Since 1896

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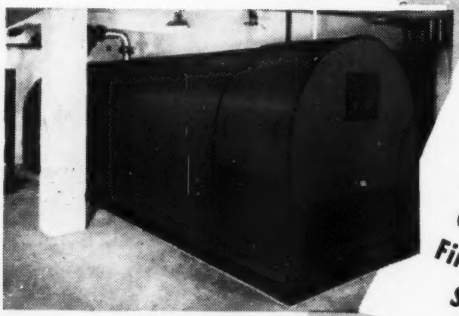

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Vol. 49 No. 2 October 1955

Quarterly

The Standard Technical Journal of Fire Protection for More Than Forty Years

The NFPA is a non-profit technical and educational organization devoted to the reduction of loss of life and property by fire with a total membership of over 15,000. The *Quarterly* is one of the publications regularly provided to members. Other membership publications include *Fire News, Advance Reports* to the Annual Meeting, a *Year Book*, and many leaflets, pamphlets and posters issued throughout the year on fire prevention and control. Six volumes of the National Fire Codes are available on an annual subscription basis, one volume free and others at reduced membership rates. For full details on available material ask for the free "List of NFPA Publications."

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Technical committees of the Association develop means to safeguard life and property through the publication of standards covering all phases of fire prevention and protection. Your membership in the Association affords an opportunity to keep abreast of these developments and, by being a member, you help support this humanitarian activity. Popular educational literature on fire safety is constantly being produced by the NFPA for distribution through its members to the general public.

National Fire Protection Association
International

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of the

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Accounts of fires appearing in the Quarterly are based on reports forwarded to the Association except where otherwise indicated. The Association, as a body, does not assume responsibility for the accuracy of the fire reports printed herein.

This publication is indexed by Engineering Index, Inc.

Chicago Tribune Photo

Automatic sprinkler protection in this fire-resistive clothing store of Maurice L. Rothschild & Co. would have simplified the fire fighting problem presented by this 12th story (192 ft. high) inferno on State Street, Chicago, on July 15, 1955. Apparently originating from a welding spark during roof installation work on an air conditioning system, the fire entered the top story through a roof opening made for the ducts and fed on large amounts of combustible shelving, stock and partitions on the 12th floor. Fortunately the store was closed for the cleaning and repair operations.

Whiting Refinery Fire

By Miles E. Woodworth, NFPA Flammable Liquids Engineer

Wide World

At the height of the fire, burning oil covers the adjacent street and flows down the railroad tracks. Barely discernible are water streams cooling the tank on the right.

Shortly after 6:00 A.M., Saturday, August 27, a violent explosion occurred in a hydroformer being brought "on stream" at the Standard Oil Company (Indiana) refinery in Whiting, Indiana. The explosion was heard as far as thirty miles away with damage to buildings occurring as far as three miles. One child, three years old, was killed while in bed when a flying piece of steel penetrated the roof of the house. A plant employee died of a heart attack shortly after reporting back to the plant for fire duty. Over thirty people suffered injuries.

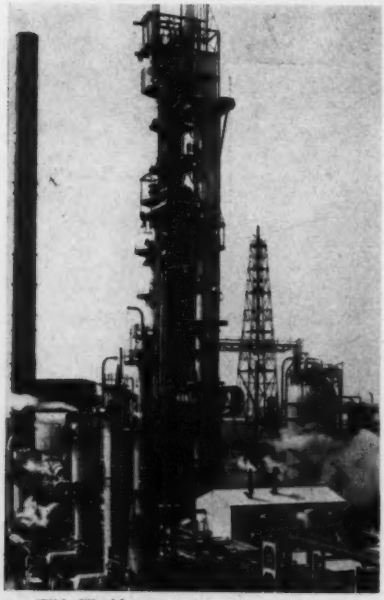
Two houses were completely destroyed, eighty received major damage and 100 were damaged to a lesser extent. Windows were broken over a three-mile area. Nine hundred and fifty families were evacuated from the endangered residential area through disaster plans of the Red Cross. The American Legion provided guard service until the Governor of Indiana ordered out the National Guard to prevent looting in the evacuated homes.

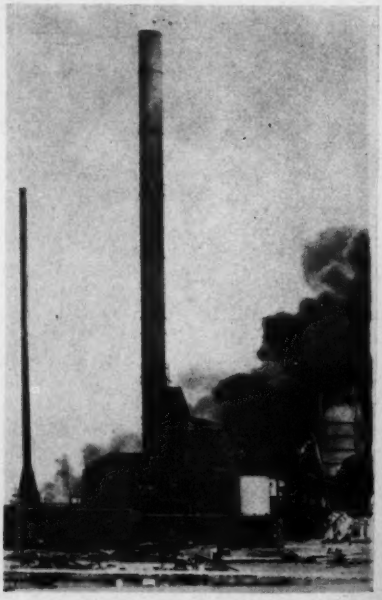
The cause of the explosion in the hydroformer is unknown at the present time. An intensive investigation by the

This is a preliminary report based on a personal investigation of the fire by the author. If further details become available following the extensive investigations being conducted by the Standard Oil Company (Indiana) which alter or significantly add to this preliminary report, they will be published by the NFPA.—Editor.

Courtesy Motorola

This view taken 30 hours after the original explosion shows the fire still burning fiercely. Intense heat has buckled railroad cars and twisted the rails.





Wide World

At left, the 265-foot-high hydroformer tower is shown upon completion. At right, taken from a slightly different angle, is what remains of the hydroformer.

Wide World

Although at one time almost completely surrounded by fire, the two tanks in this diked area were successfully protected.

company is being conducted and it is anticipated that when the cause is determined, the information will be released.

It will be some time before the full dollar loss from this fire will be known. The most conservative estimate to date has placed the loss in excess of $10,000,000 while other well-informed sources have estimated the loss in excess of $50,000,000. The total evaluation of this refinery approximated $350,000,000 and the plant employed about 7,000 persons.

Description

This refinery is the oldest in the midwest section of the United States and the fourth largest in the country.

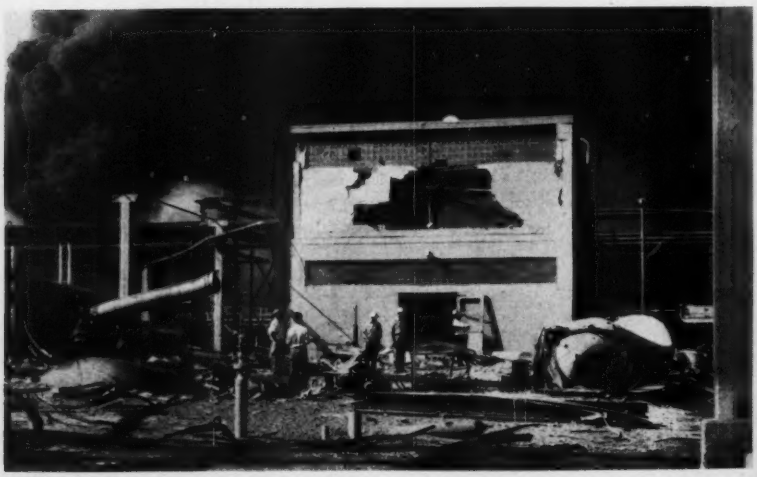
The hydroformer which exploded was nearly 265 feet high and was used to convert low octane gasoline to high octane. Although completed in March, this unit had been shut down often because it could not be made to operate correctly. In fact, it was being brought up to operating condition at the time of the explosion after being shut down for about eleven days for adjustments. The operators of the unit reported that there was nothing to indicate any possibility of an explosion and that the temperatures were only 350°F. (The unit normally operates at approximately 950°F. temperature and 150 pounds pressure.) When built the hydroformer was designed to handle 30,000 barrels of low octane gasoline a day. This gasoline is drawn into the tower and exposed to a catalyst in the presence of hydrogen. This process causes the structures of the low octane fuel molecules to be reformed into a higher octane.

The entire tower was completely shattered by the explosion, with huge pieces of the 2½-inch steel walls landing several hundred feet away. The shrapnel-like effect of these pieces of 2½-inch steel not only did severe damage to the nearby residential area but also punctured many of the adjacent storage tanks.

The explosion of the hydroformer, although causing severe damage to property and causing the direct loss of one life, would not in itself have created much of a fire. It was the rupturing of the nearby storage tanks permitting large quantities of fuel to flow from the tanks that caused

Wide World

One of the many flying steel fragments destroys a building, although how the demolished car ended up on top of the rubble is a matter of conjecture.



Elsie Boness

Flying steel fragments also damage building and equipment inside the refinery.

most of the fire. This released fuel immediately was ignited. All grades of flammable liquids from crude oil to aviation gasoline were stored in the approximately eighty tanks involved in the fire, of which 70 were destroyed or damaged. Since there were no dikes in this tank farm, it was extremely fortunate that the entire tank area was slightly below grade level of the adjoining portions of the refinery and street. The majority of the tanks in this area were over thirty-five years old and many were inadequately spaced according to the present NFPA Suggested Ordinance for the Storage, Handling and Use of Flammable Liquids (No. 30-L). The tanks varied in size from 30 to 120 feet in diameter. It has been estimated that approximately 1,000,000 barrels of flammable liquids burned in the fire. The radiated heat from the resultant fire severely damaged adjacent units in the refinery. Since five pump houses were either destroyed or severely damaged, it was not possible to pump the oil from any of the burning tanks to other tank farms on the refinery property.

Elsie Boness

Plant fire brigade proved its value by successfully confining the fire to the tank area. Note the typical emergency dike.

Fire Fighting Operations

This refinery has been recognized as having one of the best management fire prevention committees of any plant in the country along with an excellently planned emergency organization. The fire prevention committee is composed of department heads, division superintendents, general foremen, the plant fire marshal, plant safety man as secretary, and a revolving membership of key executives. A minimum of ten hours a month is spent by each of these men on plant fire protection and prevention including a monthly meeting of the group.

The plant fire marshal was in complete command at the fire. The two-way radio system was operated from the fire marshal's office with all fire department vehicles radio-equipped. The available "walkie-talkie" equipment proved to be invaluable to the plant fire marshal, since he was able to keep in constant communication with all fire areas. For fire fighting purposes the fire was divided into five areas with competent men in charge of each area. A special signal on the plant fire whistle was immediately sounded to call back off-duty personnel. At one time there were 3,500 plant employees available for fire duty.

Due to the widespread nature of the ground and tank fires, the fire fighting procedure became one of encirclement to prevent the fire from spreading to the rest of the refinery and to adjacent property. Water lines were quickly laid within the refinery to play streams of water on exposed tanks and equipment. The refinery had large aboveground water tanks and fire pumps strategically placed throughout the refinery. Although one of these was lost in the fire, there was never a shortage of water and 18,000 to 20,000 gallons per minute were being used in the refinery alone. It was soon evident that diking was necessary and dozens of dump trucks were ordered to haul in sand for diking purposes.

Although several tanks apparently ruptured in the fire, the most trouble was

Inland Steel Co.

East Chicago Fire Department moves their turret wagon.

caused by a boilover in a crude oil tank. This swept oil across the adjacent street, which is the main east-west route in this area, U. S. Route 20. The diking and the action of the public fire departments along this street prevented any spread of the fire into the homes and businesses opposite the refinery. However, burning oil did flow down the intervening railroad tracks destroying long lines of tank cars and box cars along with part of the tank car loading rack. Emergency diking was also used in the refinery.

Public Fire Department Operation

The Whiting Fire Department quickly extinguished the only fire which occurred outside the plant subsequent to the initial explosion. This fire occurred in a combination store and dwelling which was completely destroyed when a large piece of the tower struck the building and landed in the street in front of it.

Hose streams were played on tanks not yet exposed to the fire and cooling water curtains were used in other areas to protect buildings from the intense radiated heat. At first, fire companies were stationed at hydrants, one to a block, but were forced to retreat when a crude oil tank boiled over. Thirty-one firemen suffered first, second and third degree burns during the violent eruption of burning oil which is typical of a boilover. In fact, most firemen thought the tank had exploded. It is of interest to note that the firemen who were burned had removed their fire fighting coats because of the hot weather conditions (95°F). Other firemen who had not removed their fire fighting clothes were uninjured. The boilover and resultant fire in the street area necessitated rather hurried withdrawal of fire apparatus. This was successfully accomplished under extremely difficult circumstances including moving charged hose lines.

The public fire departments also aided materially in the construction of emergency dikes composed of sand and dirt hauled in by fleets of dump trucks. At one time, following the boilover, burning oil covered the entire width of Route 20, but dikes which had been improvised prevented burning oil from reaching exposed buildings. Public fire departments also supplied hose and equipment for use in the refinery.

Considerable quantities of flammable liquids found their way into sewers, which

Wide World

This view clearly shows the magnitude of the fire at its height. The extensive area involved forced fire fighters to adopt encirclement as the fire fighting procedure.

Wide World

The fire continued to burn fiercely during the second day. The remains of the hydroformer can be seen clearly in the foreground.

gave cause for concern to the entire town of Whiting. It was through the sewers that oil found its way to a ship canal which connected the industrial area of Whiting with Lake Michigan. A fire boat from the City of Chicago was called to disperse the oil on the canal.

Eight days after the initial explosion the last fire was extinguished.

Conclusions

1. Insufficient spacing between hazard areas proved to be the primary cause of the large loss. With the development of many new processes in the oil refining industry, older refineries particularly are becoming overly congested. Industry must decide whether it is better to spend additional millions to secure proper plant separation or to be exposed to multi-million-dollar property losses and multi-million-dollar losses of production.

2. Puncturing of tanks and breaking of lines resulted in the release of large quantities of the contents of the tanks which burned and exposed other tanks in the tank farm area.

3. Lack of dikes and inadequate spacing between many of the tanks proved to be an insurmountable fire fighting problem.

4. The desirability of having an adequate and detailed disaster plan for industrial and public fire and emergency organizations was clearly indicated by the fire in an extremely congested and valuable industrial area.

5. The refinery's own unusually complete disaster plan proved its worth in many ways.

(a) The accurate and detailed newspaper reporting was handled from press headquarters established in the administration building.

(b) The plant's competent fire marshal was in complete charge of the fire under the plant's emergency organization. This organization provided for maximum efficiency.

(c) The water system including fire pumps, water tanks, hose and pumpers proved the success of the preplanning and the value of such complete equipment.

(d) Two-way radios on the plant's fire apparatus and particularly the "walkie-talkies" provided instant communication with the fire marshal at fire department headquarters.

(e) The fire training of plant personnel, including plant management, proved to be invaluable.

(f) Previous visits to the plant by public fire departments and visits by the plant's fire marshal to public fire departments proved to be of value through the resultant mutual confidence and harmonious operations.

6. The cooperation between the many paid and volunteer fire companies was noteworthy.

7. Police officials, Salvation Army, National Guard, American Red Cross and other officials are to be congratulated for the handling of the evacuation, housing and feeding of the 1,900 people for a period of four days. The traffic control in itself was a monumental task.

Restaurant Blast Kills Twenty-Two

By Clark F. Jones, NFPA Gases Field Engineer

Steve Cole

Figure No. 1. Eyewitness accounts differ as to the sequence of events, but total fire destruction followed the blast, trapping most of the occupants and causing fatal injuries to twenty-two.

On Wednesday, August 10, 1955, another tragedy occurred when 22 persons lost their lives in an explosion and fire of undetermined origin in a restaurant and dairy store in the small farming community of Andover, Ohio. Seventeen other persons were injured and treated in nearby hospitals. First aid was given to numerous additional persons who were in the immediate area at the time of the blast. In addition to the loss of life, there was an estimated $250,000 property damage to the building, contents and exposures.

A preliminary report from an on-the-scene investigation by the author.

Delayed Fire Department Response

The explosion took place at approximately 7:07 P.M. while the Andover Fire Department was answering a call in an adjoining township. When firemen returned to Andover they found the restaurant and dairy store completely enveloped in flames. Fire fighting operations were then immediately initiated in an effort to help with the rescue work and to prevent the extension of the fire to exposed buildings. However, by the time the Fire Department had arrived, flames had already spread to a one story frame shoe repair shop and to the second floor of the Ohio Edison Building on the north, and to the

plumbing and heating shop on the east (see Figure No. 2).

The automatic telephone exchange for the town, located across the street to the south of the scene of the explosion, was put out of service leaving the town without normal telephone communication. Several minutes after the blast, an alert townsperson drove to the Baltimore & Ohio Railroad tower a quarter-mile away to request aid, using the railroad facilities to call nearby emergency organizations. Seventeen volunteer fire departments and nine ambulances responded to this appeal.

Events Prior to the Blast

This area was subjected to a heavy rain and severe thunderstorm of about one hour's duration immediately preceding the explosion. Streets were flooded and in some places the water was over the curbs.

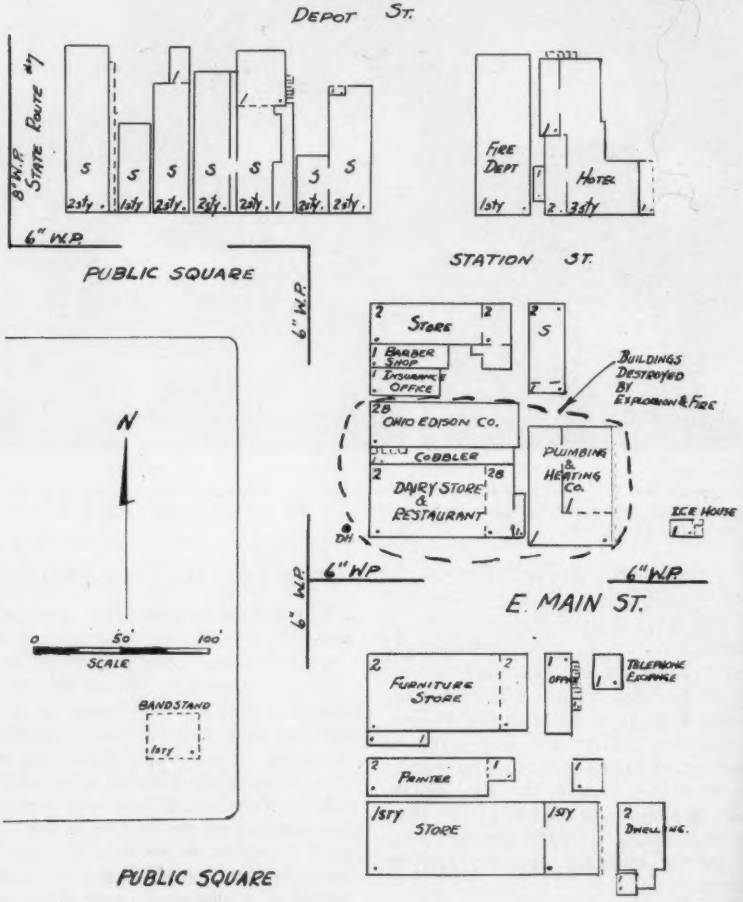


Figure No. 2. Property affected by the mysterious explosion in Andover, Ohio on August 10, 1955, which was fatal to twenty-two persons.

Robert Findley

Figure No. 3. One of the owners of the restaurant was opening the sewer drain cover (center foreground) outside the building after detecting an unpleasant odor in the structure. The explosion occurred inside the restaurant during this period.

The sewers were unable to handle all the surface water. Eye witnesses stated the storm had abated about ten minutes before the explosion. Many persons inside the building were waiting for the water to recede so they could go to their cars parked on nearby streets.

Customers who were in the restaurant prior to the explosion later reported they had been aware of a peculiar odor. This odor was not identified but one of the owners checked in the basement and then went outside to open a blocked surface drain in the sidewalk (see Figure 3). While she was doing this, the explosion occurred in the building. By being outside at the moment, the part owner's life was spared.

Description of the Building

Located on the east side of the Public Square in Andover, the building involved was a 50 foot by 90 foot two-story, frame structure with a restaurant and dairy store occupying the first floor. The second floor was vacant. A crawl space about two feet high extended under the front three-quarters of the building. A small six-foot-high basement was located in the rear quarter of the building. This is shown in Figure No. 2 on the opposite page.

The restaurant was on the south side and the partial self-service dairy store on the north side of the building. The restaurant kitchen was located in the rear southeast corner. Storage facilities and rest rooms were located behind a partition 27 feet from the rear of the building. The main entrance to the first floor was through two doors in the front or west side of the building. Two doors were located on the south side near the rear for service. Entrance to the basement was from the outside. Four 80-inch-wide plate glass windows were across the front and four double hung windows were on the south side.

Gas was used for heating water and for cooking in the kitchen. The building was heated by an oil-fired hot air furnace installed in a dug out area near the northwest corner of the basement.

The furnace was not in use at the time of the explosion. It sat on the ground with an electric driven sump pump nearby. Oil was supplied to the furnace from a 275-gallon fuel oil tank in the southeast corner of the basement. The basement also contained a number of electrically driven refrigerating units for the equipment utilized in the dairy store.

Ventilation for the building was supplied by four 2 foot diameter exhaust fans located in the outside walls. Two smaller suction type fans were installed in the canopy over the cooking ranges in the kitchen. Two pedestal type floor fans were in service in the restaurant.

After the Explosion

Stories of eye witnesses at the scene are somewhat conflicting. One stated that he was looking directly at the building about 500 feet away and it appeared that it was hit by a bolt of lightning and then flames immediately enveloped the building. Another witness observed the scene from the furniture store across the street. He stated the entire building seemed to rise from the ground, the first floor sides came out with a terrific rumble and the entire second floor dropped. The building was completely enveloped in flames. Other observers stated that fire was not present until a few moments after the blast and it seemed to build up rapidly following the appearance of dense black smoke from the rear of the restaurant (kitchen area).

Nine hours after the first explosion, or about 4:00 A.M. the following morning, the fire flared up on the north side of the building near the shoe repair shop. Several firemen reported an odor of some kind of gas. Immediately rumors were started that caused newspaper reporters to assume that natural gas leakage was the cause of the disaster.

On August 11 investigators from the Ohio State Fire Marshal's Office, assisted

Wide World

Figure No. 4. The post-fire scene was a grim sight testifying as to the force of the explosion.

by employees of the East Ohio Gas Company, conducted a complete survey of sewers, manholes, and probed along all gas lines in the vicinity, as well as some basements of buildings in the area with a combustible gas indicator. At no time was any reading of natural gas indicated. In addition to these tests, the gas meter and the gas service line to the building were salvaged from the ruins and a pressure test was conducted. The pipe and meter were found in remarkably good condition.

During the course of the fire, approximately one to one-and-a-half hours after the original explosion, the tank in the basement containing fuel oil for the furnace blew out at one end and released the contents over the basement floor. This provided additional fuel to an already intense fire.

Vapors from Sewer

Evidence of a ruptured soil pipe stack in the damaged building and samples of earth smelling strongly of petroleum products resulted in an investigation of possible contamination of the sewer system by leaking underground gasoline tanks. All nearby tanks in the vicinity were checked but no evidence of leakage has been detected to date. As in any small town, it was indicated that there may be some connection between the storm and sanitary sewers in the area. Most of the sanitary sewer manholes were sealed with asphalt from road resurfacing.

Evidence of an additional minor explosion and fire was found in the basement and first floor wash room of the Ohio Edison Building. Charring and indication of a flash fire originating from wash bowl and toilet drain openings strongly point to the fact that some flammable vapors must have been trapped in the sanitary sewer lines.

Investigation Continues

Mr. Charles R. Scott, State Fire Marshal of Ohio, has advised the NFPA office that his office is continuing the investigation of this explosion and fire. Further details will be published as they become available.

Insulated Metal Roof Deck Fire Tests

By J. A. Wilson, Engineer
Factory Mutual Engineering Division

The extent to which various combustible materials located on top of steel roof decks affect the spread of fire has been a matter of widespread interest and speculation. The Factory Mutual Insurance Companies and the Metal Roof Deck Technical Institute, being vitally interested, collaborated and developed a series of tests on a sufficiently large scale and scientifically controlled to yield authentic results representative of this construction when involved in actual internal building fires. The Insulation Board Institute being interested in the performance of combustible insulation board on top of steel roof deck also co-sponsored some of the later tests. The entire investigation required nearly two years of test work.

The fire tests were divided into two parallel tests using identical test samples each time. A large scale test was made to provide information indicative of the performance of the flat steel roof deck construction with various combustible materials on the upper surface. The principal purposes of this test were to determine to what extent these combustible materials contributed to the spread of the fire, the smoke inside the building and the building collapse. These large scale tests used a structure designed and constructed to be representative of a portion of a steel frame metal roof deck type of building incorporating the extent of restraint of structural members as in an actual building.

Tests were also made on a small scale Calorimeter Furnace in order to co-ordinate the large scale tests with the small scale tests. The identical test sample in the Calorimeter Furnace can be more accurately evaluated using instruments rather than human observation to record the performance.

Calorimeter Furnace

This furnace is a horizontal structure of rectangular cross section, the walls and roof being constructed of materials which have excellent insulating and refractory properties. At one end is a firing chamber into which gasoline fuel and air are introduced at accurately controlled rates. The gasoline fuel rate is under volumetric control and is maintained constant throughout the test. Air is introduced on a constant weight basis, regardless of the atmospheric temperature. More than three times as much air is introduced as that needed to burn the exposure fuel.

By means of baffles, excess air is thoroughly mixed with hot products of combustion in the firing chamber and is thus readily available to combine with combustibles which may be distilled from the sample under test.

The central portion of the furnace supports the sample and confines the distilled products which unite with excess air.

Further mixing of gases and any unused air takes place in a mixing chamber beyond the sample. From this mixing chamber, gases pass into a short horizontal flue where a group of thermocouples measure the temperature. This temperature is continuously plotted against time throughout the 30 minute test period.

Based on a talk presented by Mr. Wilson at the 59th Annual Meeting of the NFPA held in Cincinnati, Ohio, May 16-20, 1955.—Editor.

Figure 1. Samples 5 feet by 9 feet were tested in this Calorimeter Furnace to coordinate the results secured in the large scale test structure.

This furnace requires a 5 ft. by 9 ft. sample of the material under test.

Large Scale Test Structure

The structure was 20 ft. wide by 100 ft. long, consisting of steel columns 20 ft. on centers with longitudinal beams between them supporting steel I beam purlins 6 ft. 8 in. apart. The steel deck was welded to the purlins in accordance with the usual field practice. Steel framing, designed to simulate the purlin continuity and/or restraint which exists in a large building, consisted of restraining columns with channel tie members over the top of the structure at each purlin and connected to the tops of the restraining columns. This restraint framing was proportioned to resist the "push" of the purlins as they expanded in the early stage of the fire and the "pull" as the purlins sagged in the latter stage.

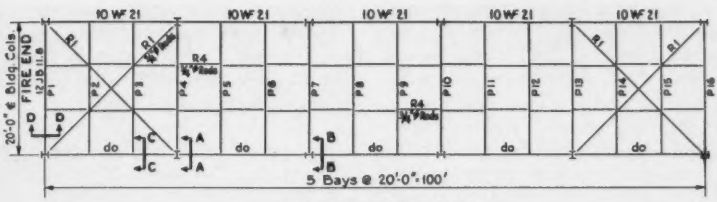
Full height walls were provided on two sides and one end, consisting of reinforced lightweight mineral tile supported by exterior wood framing. The flue end of the building was open except for a corrugated iron curtain extending down 2½ ft. from the roof.

The fire exposure was produced by two Sprayco Type 4B nozzles, atomizing gasoline in sufficient quantities to produce a rise of temperatures under the roof in the first 20 ft. of the structure approximating the Standard ASTM Time Temperature Curve (1000°F. at 5 minutes, 1300°F. at 10 minutes, 1550°F. at 30 minutes and 1700°F. at one hour). Hydrogen pilot burners were used to ignite the gasoline. To insure a positive and independent source of ignition, the hydrogen burners were piloted by electric spark created by a 10,000 volt transformer. Two Fireye combustion safe-

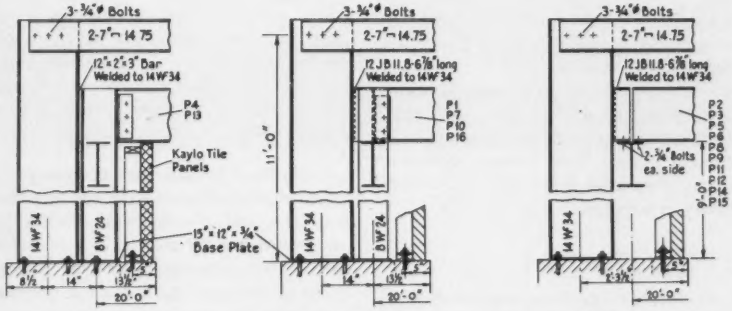
Figure 2. The large scale test structure used in these tests was 20 feet wide by 100 feet long. This view is from the "fire end" where the atomizing gasoline burners were located. The "flue end" of the building was open except for a corrugated iron curtain extending down 2½ feet from the roof.

guards were installed and arranged to give an alarm in case of flame failure. The combined fuel rate delivered to the two burners was 1.0 gallons per minute for the first 2 minutes, 1.5 gallons per minute for the next 2 minutes, 2.0 gallons per minute for the next 3 minutes, 2.5 gallons per minute for the next 10 minutes, and 2.7 gallons per minute for the balance of the test.

Air needed for the combustion of the gasoline and for any combustibles contributed from the roofing materials

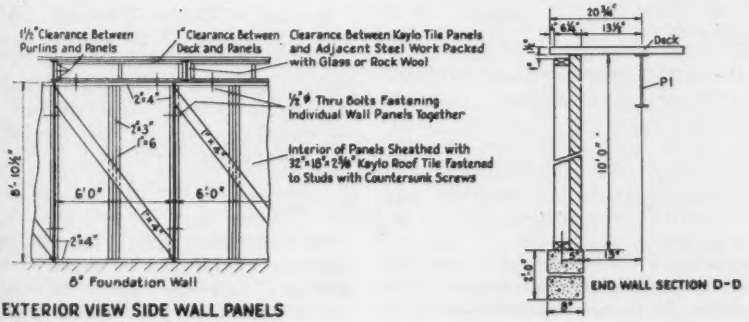


ROOF FRAMING PLAN
RESTRAINT FRAMING OMITTED



SECTION A-A SECTION B-B SECTION C-C

SECTIONS SHOWING RESTRAINT FRAMING
PROVIDED AT EACH END OF EACH PURLIN


1⅛" Clearance Between Purlins and Panels
1" Clearance Between Deck and Panels
Clearance Between Kaylo Tile Panels and Adjacent Steel Work Packed with Glass or Rock Wool
½"ϕ Thru Bolts Fastening Individual Wall Panels Together
Interior of Panels Sheathed with 32"x18"x2⅜" Kaylo Roof Tile Fastened to Studs with Countersunk Screws
8'-10½"
6'0"
8" Foundation Wall
Deck
P1
10'0"
END WALL SECTION D-D

EXTERIOR VIEW SIDE WALL PANELS

Figure 3. Details of the test structure. Note that the purlins are numbered 1 through 16 starting from the fire end. The text frequently reports the fire test behavior by use of these numbered purlins.

was supplied by a blower located outside the test building. The air supply, totaling 5500 cfm at 70°F., was delivered by four ducts through the end wall of the test building. Two ducts were located at about two-thirds the height of the building and discharged air to the two burners which were positioned in front of the ducts. The other two ducts were located at about one-third the height of the building and discharged air into the structure.

Thermocouples, 28 in all, recorded fire exposure temperatures at the burner end of the structure and steel temperatures throughout. These were 20 gage asbestos covered, glass insulated chromel-alumel thermocouples. All thermocouples outside of the test building were in steel conduit 10 feet above the ground, extending to the recorders in the instrument house. Two Brown automatic recorders were used in all tests and, where necessary, a supplementary recorder.

Test Work

Considerable preliminary investigation was necessary to develop an adequate test fire (in terms of sufficient heat input, rapidly enough to create high ceiling temperatures required and to maintain this high temperature over a period of time) that would cause asphalt or other combustibles on top of the steel roof deck to contribute to an interior fire.

It was also necessary to establish the basic temperature gradient (for the above fire exposure) along the underside of the roof of the test structure for a completely noncombustible roof assembly, where the heat insulation and retention values were similar to an insulated steel deck yet none of the materials could contribute to the test furnace heat. This gradient was necessary to show the extent to which the introduction of combustible materials on top of the steel roof deck, used in subsequent tests, would contribute to an interior fire.

Six fire tests have been conducted on different constructions using various typical construction methods, varying only one material each time to obtain the exact contributing factor.

The period of test fire exposure for all tests was 30 minutes, except for Test No. 1, which was 60 minutes.

Test No. 1

PURPOSE. This test was for the purpose of showing if a severe exposure fire would damage the steel deck and the framing so that asphalt and other combustible roof materials to be used in subsequent tests might contribute to the interior fire, and to establish the basic temperature gradient throughout the length of the building for this fire exposure. All materials in the roof construction were noncombustible.

CONSTRUCTION. Loose vermiculite 1½ inches thick was placed on the 6-inch-wide steel deck and covered with asbestos paper over which was placed a 1 inch thickness of sand. This construction was the equivalent of the dead weight and insulating qualities of a normally used insulated roof covering.

PERFORMANCE. Twisting and sagging of the purlins started over the fire at 8 minutes and 10 seconds, and progressed gradually toward the flue end of the building being very pronounced in the first 40 feet.

RESULTS. Deflection of the steel deck followed the sagging of the purlins, being a maximum of about 2 feet near the fire end where it opened in several places permitting sand to sift through. At 27 minutes and 30 seconds, daylight was visible through the deck where it had opened.

Test No. 2

PURPOSE. The purpose of this test was to determine whether a roof construction embodying a 2-ply vapor barrier between the deck and insulation would contribute to the interior fire and building damage.

CONSTRUCTION. The roof covering consisted of a 3-ply tar and gravel built-up cov-

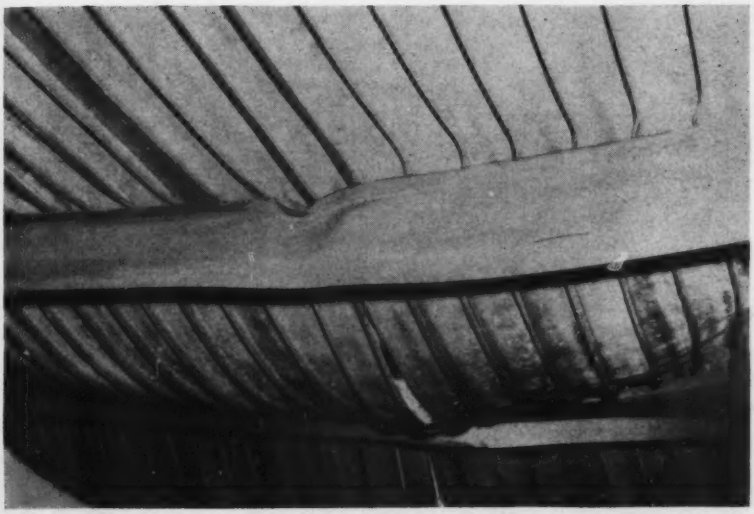


Figure 4. Deformation of steel deck and beams at the fire end of the test building following Test No. 1. All materials in the roof construction in this test were noncombustible.

ering on 1 inch nominal thickness of fiberboard insulation on a 2-ply asphalt saturated rag felt (three mop) vapor barrier. The three moppings of standard 180°F. roofing asphalt were applied at the rate of 22½ lbs. per mopping per 100 sq. ft. (i.e., 0.675 lbs. per sq. ft. between top of steel roof deck and under side of insulation board). This is considered to be the greatest amount of combustibles used in building practice.

PERFORMANCE. Flaming on the underside of the roof started over the exposure test fire at 5 minutes and 30 seconds, and progressed so rapidly that at 10 minutes and 30 seconds, flames and heavy smoke were discharging from the flue end of the test building. Burning asphalt was dripping through the joints of the steel deck over the fire at 5 minutes and 50 seconds. Unburned gases reduced visibility in the test building to zero at 8 minutes and 15 seconds. Yellow vapors in considerable volume escaped to the atmosphere along both edges of the roof for the full length of the building. Upward bulging of the roof covering occurred in several places during the test. This indicated that combustible gases forming within the construction could not be liberated through the joints of the steel deck at a rate sufficient to prevent pressure from being exerted on the underside of the roof covering above the insulation.

RESULTS. All purlins were twisted and deflected a varying amount, being less pronounced at greater distances from the exposure fire. Deflection of the steel deck followed that of the purlins. Over the exposure fire area and between purlins, the sag was pronounced and longitudinal joints were pulled apart.

Flaming on the underside of the roof gradually ceased, following the shutting off of the exposure fire at 30 minutes, and at 38 minutes flaming was confined to an area between purlins 11 and 12. All flaming had ceased at 52 minutes and 50 seconds.

All asphalt mopping of the vapor barrier and the asphalt saturant in the vapor barrier felts were consumed. Charring of the fiberboard insulation was progressive. Over the fire area, the insulation was completely destroyed and at the flue end charred to a depth of ⅝ inch.

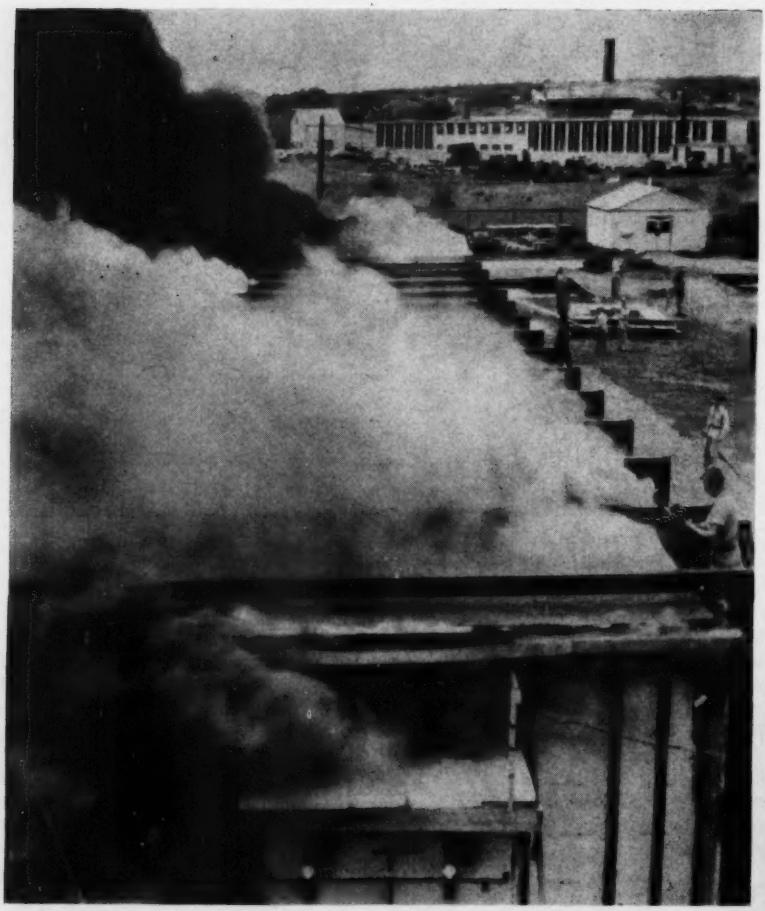


Figure 5. Smoke and flames during Test No. 2 after 11 minutes, 50 seconds. It was determined that the combustible roof covering used in this test contributed considerably to the interior fire.

CONCLUSION. The roof construction above the steel deck contributed considerably to the interior fire and building damage.

Test No. 3

PURPOSE. The purpose of this test was to determine how a vapor barrier of felt with a special saturant covered with glass fiber insulation and built-up roofing would contribute to the interior fire and building damage.

CONSTRUCTION. The roof construction consisted of the vapor barrier cemented to 18 inch wide steel deck, 1 inch nominal thickness glass fiber insulation cemented to the vapor barrier and 3-ply tar and gravel covering above. The insulation consisted of a fiber glass core covered on top with kraft paper firmly bonded with asphalt and bound around and under each end a distance of 3 inches. The vapor barrier consisted of a 60 lb. saturated felt laid with 2 inch side laps and 6 inch

end laps. The cement had the appearance of a mixture of asphalt and filler, and the two moppings were applied in 6 inch wide strips, 12 inches on center. About 0.7 gallons (0.6 lbs.) were used per 100 sq. ft. for the moppings and sealing of side and end laps of the vapor barrier. Laboratory tests showed this cement had a Cleveland Open Cup flash point of 195°F. and fire point of 325°F.

PERFORMANCE. Flaming on the underside of the roof started over the fire area at 6 minutes and 30 seconds and progressed rapidly. At 12 minutes and 50 seconds, flame and smoke were being discharged from the end of the building but to a somewhat lesser extent than in Test No. 2.

The exposure fire was shut off at 30 minutes and flaming under the roof was observed at 31 minutes near the fire end of the structure and about midway of the length of the building. All flaming ceased at 40 minutes and ten seconds.

RESULTS. All purlins were twisted and deflected a varying amount, being less pronounced at greater distances from the exposure fire. The steel deck sagged with the purlins, being quite pronounced in the first 40 feet of the test building.

CONCLUSION. This construction contributed to the interior fire and building damage but to a lesser extent than the construction used in Test No. 2.

Test No. 4

PURPOSE. The purpose of this test was to determine to what extent the fuel contribution of the roof construction would be reduced by eliminating the combustible vapor barrier and adhesives between the insulation and the deck by the use of mechanical attachment of the insulation.

CONSTRUCTION. The previous tests demonstrated that restraint of the purlins and welding of the deck to them were not significant factors in the spread of fire under the deck. To minimize structural damage, the purlins were not fastened to the restraint columns, and only loosely connected to the longitudinal supporting beams, permitting them some free-

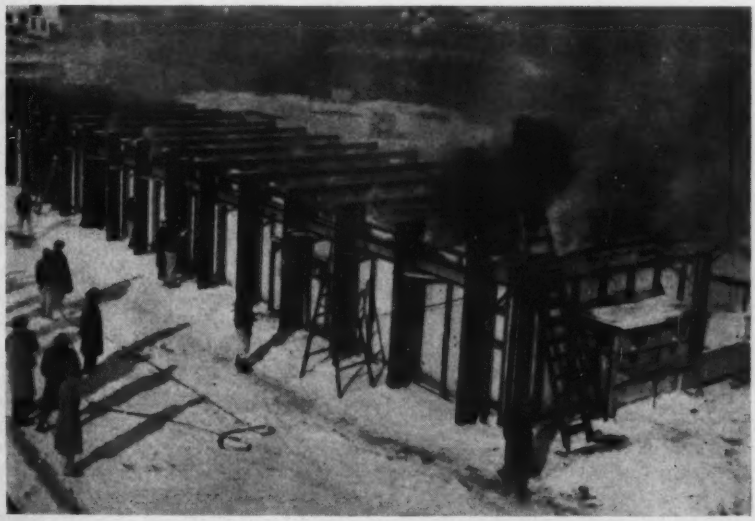


Figure 6. In Test No. 4, the combustible vapor barrier and adhesives between the insulation and deck were eliminated. The result was that the construction contributed less to the interior fire than the constructions used in Tests No. 2, 3 and 5.

dom to expand and contract longitudinally. To prevent horizontal expansion and contraction of the steel deck from exerting forces on the top flange of the purlins, and to maintain longitudinal continuity of the steel deck, ⅛ inch steel plates 4 inches wide were used on top of the purlins to which the deck was welded in accordance with the usual field practice.

The roof construction consisted of a tar and gravel covering on 1 inch nominal thickness of fiberboard insulation on 18 inch wide steel deck. The covering was mopped to the insulation and the insulation secured to the deck with mechanical fasteners. No vapor barrier or asphalt was used between the insulation and the deck.

PERFORMANCE. Flaming on the underside of the roof started over the fire exposure area at 6 minutes and progressed gradually along the underside of the roof to purlin No. 9 at 17 minutes and 30 seconds. Intermittent flaming on the underside of the roof occurred between purlins Nos. 9 and 12 during the latter stage of the test but did not extend beyond purlin 12. All flaming ceased in 6 minutes after the exposure fire was shut off at 30 minutes.

RESULTS. Practically no twisting or deflection of the purlins occurred beyond purlin No. 6. A large sag in the roof occurred under purlin No. 2 but the steel decking did not open up exposing the insulation.

The thickness of the insulation completely destroyed varied from ⅜ inch over the fire area to 1/16 inch at the flue end of the test building. Discoloration of the insulation above the destroyed area varied from ⅜ inches over the fire area to 1/16 inch at the flue end of the building.

CONCLUSION. This construction contributed less to the interior fire than the constructions used in Tests No. 2, 3 and 5.

Test No. 5

PURPOSE. The purpose of this test was to determine the fire behavior of an insulated roof construction without a vapor barrier, but with the insulation mopped to the deck with asphalt.

CONSTRUCTION. The construction consisted of a tar and gravel covering on 1 inch nominal thickness of fiberboard insulation on 18 inch wide steel deck. In this test also the purlins were not restrained. The roof covering was mopped to the insulation and the insulation strip mopped to the deck using 12 lbs. of asphalt per 100 sq. ft. of roof deck. The mopping was applied in 6 inch wide strips on 12 inch centers leaving an unmopped strip of deck 6 inches wide between the asphalt.

PERFORMANCE. Flaming on the underside of the roof was well established over the fire area at 6 minutes and progressed slowly toward the flue end of the test building, reaching purlin No. 8 at 8 minutes and 35 seconds and the end of the building in 12 minutes 50 seconds. Within 2 minutes, a large volume of flame and dense yellow smoke was being discharged from the end of the building. Prior to active flaming being established on the underside of the deck over the fire area, some leakage of asphalt through the joints of the steel deck was observed. Only lazy flaming was visible on the underside of the deck just beyond the exposure fire at 18 minutes 50 seconds and the volume of flame and smoke discharging from the end of the building had lessened considerably at 20 minutes and 55 seconds. Flaming on the underside of the deck diminished rapidly toward the end of the test and when the exposure fire was shut off at 30 minutes, flaming in scattered spots at the top of purlins existed but went out very quickly.

RESULTS. In this test, also without restraint, the 5 purlins over the fire end of the test building were badly twisted and deflected. Purlins Nos. 6 and 7 were twisted from the horizontal about ½ inch. Practically no damage occurred to the balance of the purlins. The deck itself deflected with the purlins without any of the joints opening.

All asphalt between the deck and the insulation was entirely consumed over the whole roof area. The thickness of insulation completely destroyed varied from ⅜ inch over the fire and to about ½ inch at the flue end of the test building. Discoloration indicating scorching of the insulation above the destroyed area varied from ⅜ inch over the fire area to about 3/32 inch in the vicinity of purlin

No. 12. Beyond this area, practically no discoloration existed above the completely destroyed thickness of insulation.

CONCLUSIONS. Contribution to the interior fire was somewhat greater in the early stage of the test and somewhat less in the latter stage than that contributed by the construction used in Test No. 3.

Test No. 6

PURPOSE. The purpose of this test was to determine to what extent Lexsuco* above deck construction would contribute to the spread of fire beneath the steel deck.

CONSTRUCTION. The Lexsuco construction was applied to 1½ inch deep, 18 gauge steel roof deck, placed in a manner similar to that used in Tests 4 and 5. This arrangement permitted expansion of the deck independent of the purlins.

Adhesive of reclaimed rubber base with chlorinated ethylene solvent, was first applied to the steel deck by means of a roller coater using 1.7 lbs. (dried weight) per 100 sq. ft. A Koroseal Vapor Barrier, a specially compounded poly-vinyl chloride sheet 0.004 inch thick and 32 inches wide, was laid over this coating and lapped 1 inch. Ribbons of Lexsuco Adhesive about 6 inches apart were laid over the Koroseal Vapor Barrier prior to laying the 1 inch vegetable fiberboard insulation.

A strip of 30 lb. asbestos felt, coated with Lexsuco Adhesive was laid on top of the insulation, and on top of this 30 lb. felt a Glasfab* membrane fabric was laid. Lexsuco Fi-

*"Lexsuco" is the trade name of Lexsuco Incorporated, 4815 Lexington Avenue, Cleveland 3, Ohio. Test No. 6 reports the Factory Mutual tests on this company's above deck consruction.

*"Glasfab" is described by the manufacturer as "an inert waterproofing membrane loom woven entirely of inorganic 'Fiberglas' yarn."

Figure 7. The Lexsuco adhesive and Koroseal vapor barrier being applied in preparation for Test No. 6.

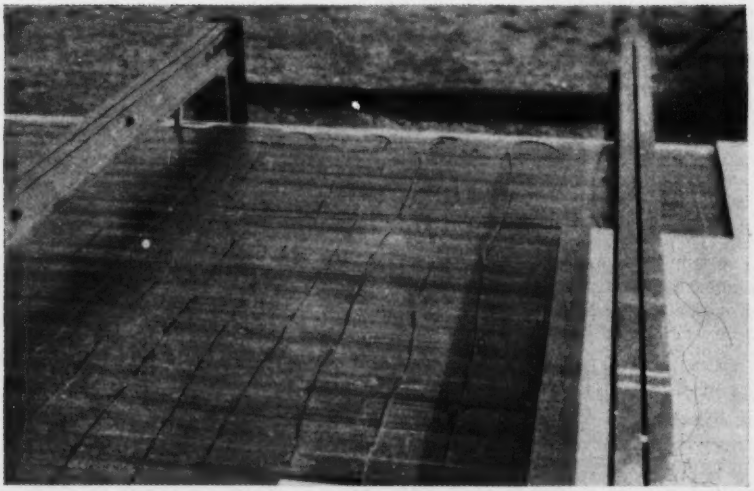


Figure 8. Over the vapor barrier, ribbons of adhesive are laid to attach fiberboard insulation for Test No. 6.

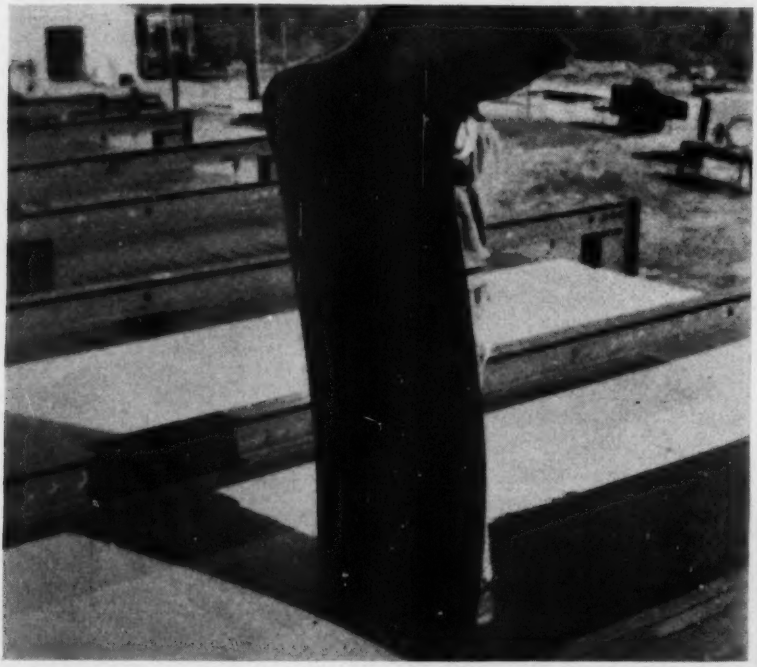


Figure 9. Showing the application of the 30 lb. asbestos felt which is applied over the insulation.

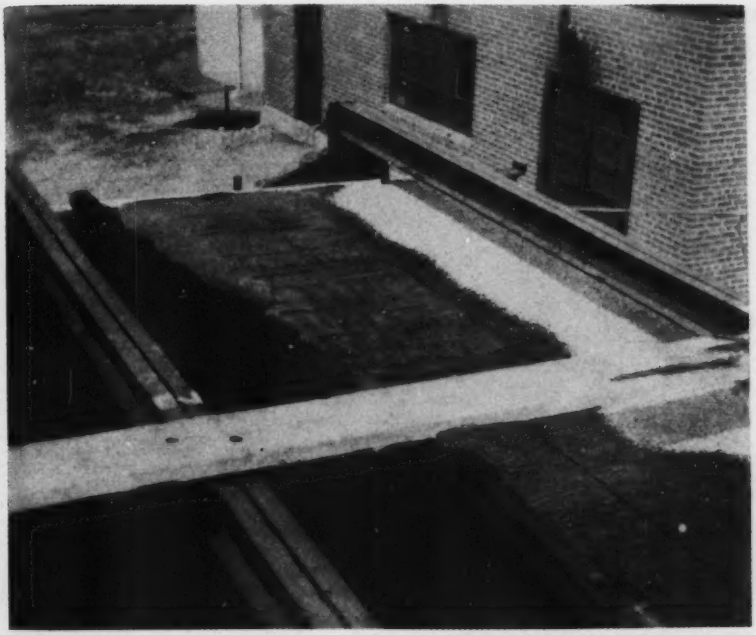


Figure 10. Roof deck covering is completed for Test No. 6 with Glasfab, Lexsuco fibrated roof coating, and gravel.

brated Roof Coating was squeezed into and covered the Glasfab to form a tight, resilient, weatherproof surface. The surface of the roof was then covered with a layer of gravel.

PERFORMANCE. Flaming under the roof did not advance beyond 57 feet from the firing end. Vigorous flaming under the deck ended between ten and eleven minutes after the start of the test, although some intermittent flaming at isolated locations was reported until the end of the 30 minute test.

It is interesting to note that in this test, practically all gases given off around the edges of the firing end of the structure were white, similar to steam in appearance, as contrasted with black and yellow fumes produced in previous tests when asphaltic material was present between the insulation and the deck. The white smoke was generally confined to the firing end of the structure and was in considerably less volume than when asphaltic materials were present. Throughout the test there was no appreciable volume of smoke which, in an actual fire, would interfere with manual fire fighting. Gasoline exposure burners were visible throughout the test.

RESULTS. Purlin and steel deck damage was confined to the firing end of the large structure. Only four purlins were damaged beyond re-use. The insulation on the steel deck after the test was damaged as follows:

At the extreme end away from the fire end of the furnace, the Koroseal Vapor Barrier was gone as well as most of the Lexsuco Adhesive. Coked residue of Koroseal and Lexsuco Adhesive was shiny black with a metallic appearance. Insulation was discolored from dark brown reducing to normal in color at 50 per cent of thickness.

At the center of the test building the coke residue was the same as above but the insulation was charred to a depth of ⅛ inch and discolored ⅜ inches deep.

Just beyond the test furnace flame the insulation completely charred but was still in-

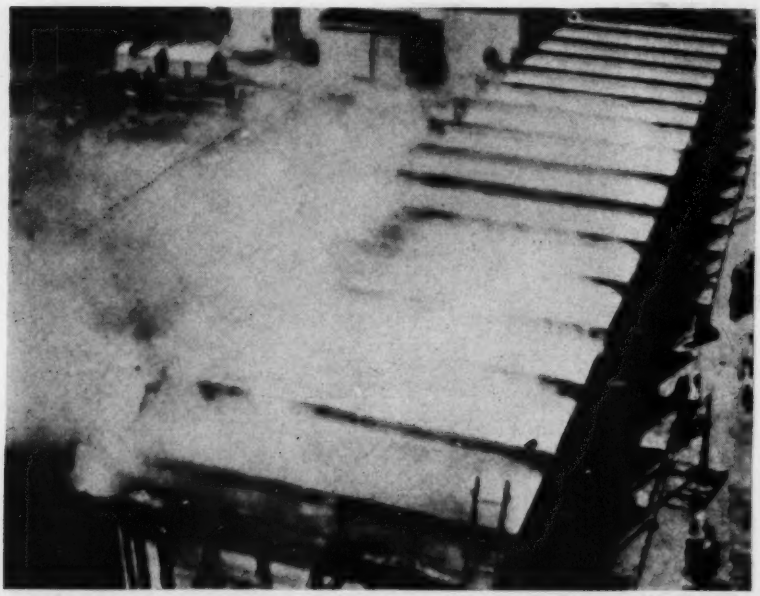


Figure 11. During Test No. 6 the absence of dense volumes of smoke was most notable. It was concluded that the Lexsuco Vapor-Barrier-Adhesive combination test made no contribution to the spread of fire within the building.

tact and reduced to 50 per cent of its original thickness. The Lexsuco Adhesive used to attach the felt to the insulation still adhered to the felt and retained its plasticity.

It is significant that at no time during this test was it necessary to apply water to the wooden protective shield at the exit end of the structure, although in all previous tests such protection was needed.

CONCLUSIONS. It is concluded that the Lexsuco Vapor Barrier-Adhesive combination tested makes no contribution to the spread of fire within a building. When used with combustible 1 inch vegetable fiberboard insulation, extensive spread of fire beyond the zone of direct exposure did not occur under the test conditions.

Calorimeter Furnace Tests

All constructions tested on the large 100 ft. by 20 ft. test structure were also tested on the Calorimeter Furnace and the results compared to the large tests. After the data from several tests had been compiled it was evident that the performance in the large test could be very accurately predicted.

This Calorimeter test showed that the construction tested as No. 6 contributed substantially less heat within the furnace than did the vegetable fiberboard mechanically fastened directly to the steel deck.

What the Tests Showed

The tests demonstrated that the presence of highly combustible materials, such as asphalt in the vapor seal and/or adhesive between the insulation and the metal deck, governed the spread of fire beneath the roof within the building when the underside of the roof was exposed by the test fire.

When the vapor barrier and adhesives are highly combustible, flame impingement or fire temperature on the

underside of the deck causes unburned gases in the combustible vapor barrier and combustible adhesives immediately above the deck to be liberated. These gases cannot escape up through the roof covering and, consequently, are forced down through the joints of the steel deck into the building where they are ignited by contact with flame or high temperature. It is not necessary for the fire exposure to open the joints of the steel deck for this action to occur. This flow of gas under pressure is primarily responsible for spread of fire on the underside of the deck although dripping of asphalt into the building could be a contributing factor.

When the combustible vapor barrier and adhesive were eliminated, and either mechanical fastening of the fiberboard insulation or less combustible vapor barrier and adhesive used, the application of the test fire did not produce a fire that spread extensively beyond the zone of exposure.

Any combustible material above or attached to the top of the insulating medium in the built-up roofing will not contribute directly to the initial fire spread under the steel deck prior to a major collapse of the building framing and roof.

In the tests, the exposure fire subjected the structural steel to temperatures which resulted in local distortion and which could have produced structural collapse in a steel frame building.

Asphaltic materials in the vapor barrier and/or adhesive will contribute to a fire directly below the roof whenever a local fire exposure creates a sustained temperature of about 800°F. or higher at the underside of the deck. For the fire to spread extensively beyond the zone of direct exposure, the burning of combustibles from just above the deck must liberate sufficient heat to produce a temperature of 800°F. or more beyond the leading edge of the fire. Under the conditions represented by the tests, the following constructions on top of the deck *can* be expected to produce an underside-of-the-deck fire that will spread beyond the zone exposed.

1. Presently used vapor seals consisting of felts and asphalt regardless of whether fibreglas or fibreboard insulation is used.

NOTE: The test program did not include any test to show the minimum amount of asphalt adhesive, if any, with any type of insulation that would produce an extensively spreading fire.

2. Asphalt adhesive mopping of 12 lbs. or more per 100 sq. ft. with fiberboard insulation.

Under the conditions of the tests, the following construction on top of the deck would *not* be expected to produce an extensively spreading fire:

1. Fiberboard insulation mechanically fastened to the steel deck with no asphaltic material between the insulation and the deck.

2. Fiberboard insulation fastened to the steel deck with slow burning vapor seal using a slow burning nonvolatile adhesive.

3. Fiberboard insulation fastened to the steel deck using a slow burning nonvolatile adhesive.

Publicizing Your Plant Fire Safety

Fire safety is a personal thing to the employees of the Marathon Corporation.

Personalizing fire safety is the secret of an effective program aimed at continuity of production.

On the next eight pages of this issue of the QUARTERLY is a reproduction of an article that appeared in the January-February 1955 issue of *Maralog,* the house organ of the Marathon Corporation of Menasha, Wisconsin. In the opinion of the Editors of the QUARTERLY it is one of the finest illustrations of effective publicity in the interest of plant fire safety to reach our attention.

The *Maralog* is printed by the Marathon Corporation for both internal (employees) and external (stockholders, customers) circulation. The story "Fire Protection — a Job that Leaves Nothing to Chance" would seem to accomplish the following objectives for which publications of this type are designed

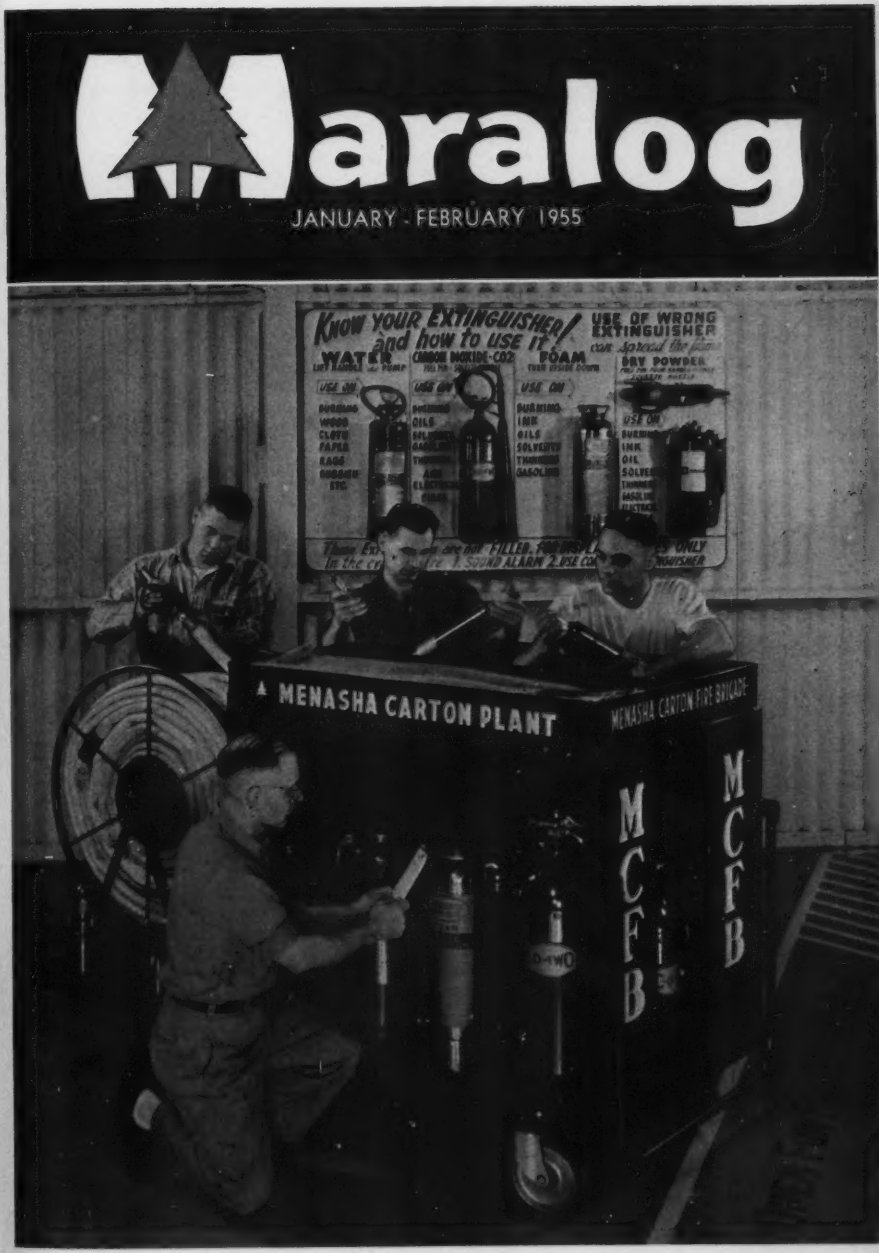
It makes the employees feel that they are important members of the Company. Note the emphasis on the plant fire brigade, the personalization of the illustrations, the emphasis the company places on protecting its employees from accidental fires.

It places emphasis on the fact that Marathon plants are good places to work. Nothing is left to chance to safeguard the plant by day or by night and job security is thereby secured. Automatic sprinklers and carbon dioxide systems stand guard twenty-four hours a day so that there is a minimum chance of arriving for work only to find that fire has burned up tomorrow's pay check.

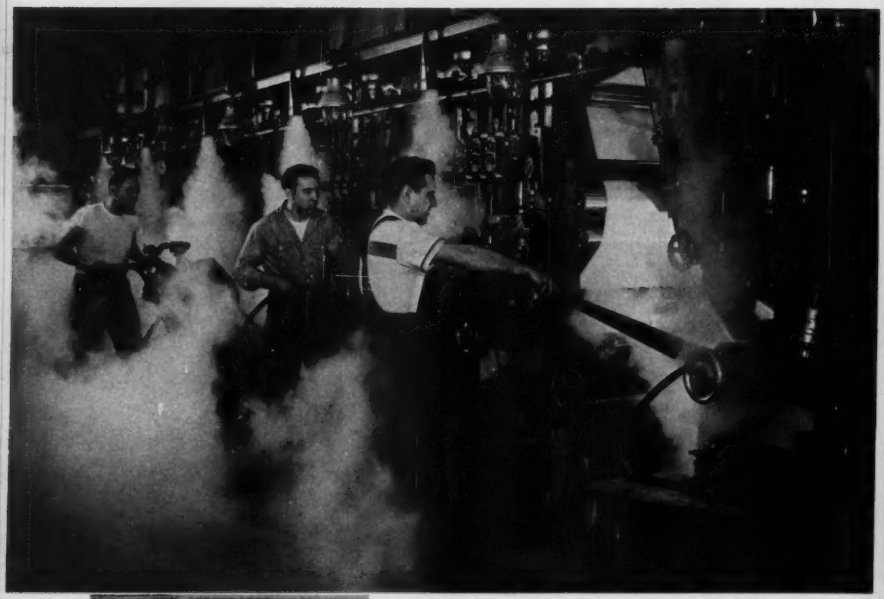
It gives employees and shareholders pride in the Marathon Corporation enabling them to speak authoritatively about what the Corporation has in the way of fire protection. This makes them good public relations envoys for the company. They will tell others that Marathon thinks first about safety and does the job well and economically by combining automatic protection and employee participation.

It maintains faith in the American economy system. Profit seeking is not done at the expense of cutting corners on employee safety.

Congratulations, Marathon!


Maralog
JANUARY - FEBRUARY 1955
KNOW YOUR EXTINGUISHER and how to use it
USE OF WRONG EXTINGUISHER can spread the fire
WATER
CARBON DIOXIDE - CO2
FOAM
DRY POWDER
MENASHA CARTON PLANT
MENASHA CARTON FIRE BRIGADE
MCFB
MCFB

Fire Protection . . . a Job that leaves



There's plenty of action as these men test fire fighting equipment on a Menasha Parafilm rotogravure press. Manual extinguishers are directed by pressman helpers Gene Sedo and Gordon Brockman and pressman Gene Koslowski. Built-in carbon dioxide extinguishers operate automatically.

On the Cover

Ready for instant use is the Menasha carton plant's mobile fire cart. Its equipment receives a periodic checkup by fire brigade members Dick Broas, Dwight Plucker, George Logan and Ralph Schroeder, kneeling. The cart is equipped with extinguishers for all types of fires, plus hose and nozzles. Other items, such as a blanket for first aid use, are carried on top. Location also has a fire information panel.

Maralog

January-February 1955
MARATHON CORPORATION
Menasha, Wisconsin
MANUFACTURING OPERATIONS
Ashland, Green Bay, Menasha, Rothschild and Wausau, Wis.; Menominee, Mich.; Modesto, Cal.; Oswego, N. Y.; Sunnyside, Wash.
Subsidiary at Marathon, Ontario, Canada.
SALES OFFICES
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Nothing to Chance

Nothing is left to chance when it comes to protecting Marathon people and the company's plants from fire. But, in case of fire, employees are trained to whisk from regular jobs into predetermined fire fighting roles.

A pressman might become a hose tender, a machinist a brigade chief, or a millwright a mobile fire truck attendant. Their job — to control the fire until arrival of the city's fire department.

That's during working hours. What happens during non-working periods if there's a fire? One answer is a company watchman who is trained to keep on the alert for a flame, to turn in an alarm and to control the blaze.

If there's no watchman to spot the start of a fire, or if fire gets underway during working hours but plant fire fighters are located some distance away, what then?

Marathon's answer is a system of automatic devices that do two things:

(1) They turn in an alarm that warns employees and calls the fire department.

(2) They fight the flame.

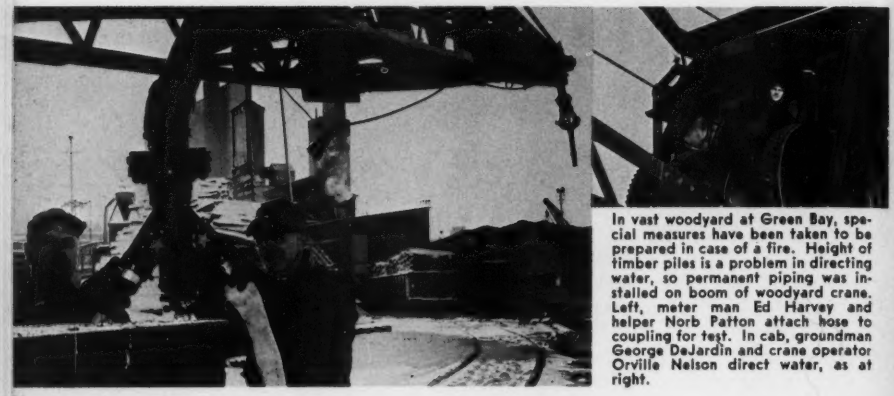
Every possible precaution is taken for three basic reasons: (1) To protect lives. (2) To protect jobs. (3) To protect customers who depend upon us for

If fire occurs at Menominee, automatic sprinkler device or manual control sounds plant alarm, informs fire department, lights up annunciator. Men go to annunciator. Illuminated number signifies fire area that's located on numbered map. Utilities engineer Ken Pape reviews annunciator with super calender operator Les Doepke, building service foreman Dan Homa, waxer operator John Gyllenberg.

Discussing alarm system are chief plant engineer Harry Gochnauer, insurance manager Bill Urban, plant protection engineer Larry Schloemer and manufacturing production managers Lee Heroman and Ed Den Dooven. This group evaluates Marathon's fire protection needs.

Many Rothschild employees are volunteer firemen with village fire department. On a test run are first stage bleacherman John Dorshak; village fire chief William Palm; paper machine backtender Harvey Kamke and quality control supervisor Arnold Doepke. Plant is in background.

At Wausau, plant protection supervisor Wally Viach places fire extinguisher in case while building serviceman Paul Preisig prepares another. Fire display acquaints employees with protective measures.



In vast woodyard at Green Bay, special measures have been taken to be prepared in case of a fire. Height of timber piles is a problem in directing water, so permanent piping was installed on boom of woodyard crane. Left, meter man Ed Harvey and helper Norb Patton attach hose to coupling for test. In cab, groundman George DeJardin and crane operator Orville Nelson direct water, as at right.

prompt service, especially when it comes to packaging for perishable foods.

How do we protect our plants from fire? It takes a combination of men, methods and devices. Each plant does not employ every measure that another does because all do not have identical problems. But each does follow a protection pattern.

Suppose we examine a combination of all Marathon plants that stretch across the United States and into Canada and see how protection measures add up.

In construction of a Marathon plant, materials are selected with a continual eye toward fire resistance, not mere building economy. Walls and floors are built not only for climatic conditions, but to confine fire to the smallest area possible if fire should occur.

Windows are designed not only for light and ventilation, but so they'll close to keep fire from entering the building. A roof is erected to withstand not only rain or hail, but fire.

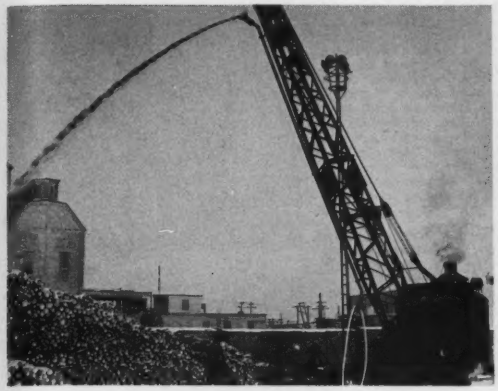
Modern construction calls for concrete or steel columns. To prevent weakening of structural steel from high

At Modesto, workman installs piping for automatic sprinkling system. Sprinklers are considered most reliable means to control fires.

Maintenance man Houston Galloway and plant superintendent Doug Trish at Sunnyside check a water line and valve supplying sprinkler.

Here's what happens when heat causes fusible metal head of a sprinkler system to open. Water output can exceed rate of heaviest rainfalls.

Millwright Willard Jahsmann and electrician Bill Montay keep Wausau fire pump in working order. Pump provides pressure to send a strong flow of water through sprinkler system and other fire protection piping.



Gene Rothe works at tank of flammable solvent to clean ink pails at Menasha Ink plant. Safety lid closes when heat melts fusible link.

heat of a fire, water from sprinkler systems keeps steel columns cool.

Superior plant protection at Marathon means well lit exits, plus fire walls to divide large areas. A wall prevents a local fire from sweeping through a plant and becoming a major conflagration.

Location of flammable liquids is a prime consideration to avert explosion in case of fire. Pipes are laid from distant pumphouses to our plants.

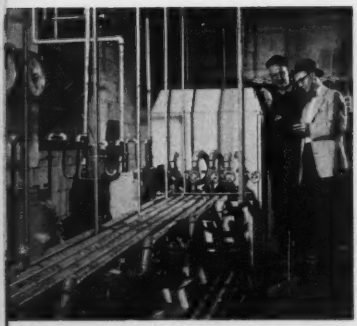
Water is a must. Most of our plants have natural, primary water sources. Large gravity tanks or reservoirs pro-

At the Menasha carton plant, plant protection and building service supervisor Loren Spence issues cutting and welding permit to building serviceman Carl Fahrenkrug and welder Oscar Myers. Permit requires fire precautions. Carl mans extinguisher. Tarpaulin stops sparks.

Chief John Duguay and pumphouse operator Frank Balas send water into woodyard pipe lines normally kept empty during winter at Marathon, Ont.

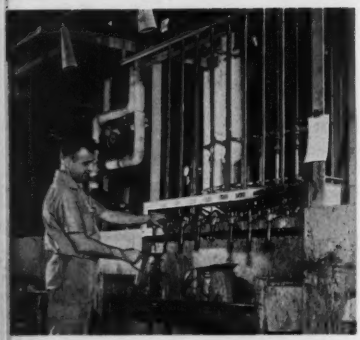
Recharging partially used fire extinguishers at Ashland are plant engineer Martti Lundstrom, millwright Frank Ludwig and quality control supervisor Gil Paulson. Extinguishers contain either chemicals or water.

Pipefitter Maurice Lamson inspects one of hose houses that encircle Oswego plant. Insurance inspector Richard Hammerl observes. Gravity water tank is in background.



Flammable ink solvents are blended in specially designed building at Menasha as precaution against fire, then piped to Parafilm plant for use. Surrounded by many pipes which run from underground storage tanks to mixing apparatus, solvent mixer Grover Smith and ink plant superintendent Dick Mathews discuss a blending schedule.

Friction, a major cause of fire, is reduced by Sunnyside maintenance man Elmer Blumquist, who reassembles a motor that's been cleaned.



Next, solvents are pumped to sinks in the Parafilm plant pressroom. Relief foreman Andrew Swiontek draws one of prescribed solvent mixtures from tap. Sink is protected by bank of C-O-Two extinguishers, above, that pour cloud of carbon dioxide gas over area in case of rapid rise in temperature. At same time, fire alarm is sounded.

Public address system at our Marathon, Ont., mill relays fire alarms. Steam plant superintendent Phillip Morgan stands by while stationary engineer Hugh Kerr prepares to transmit alarm. Meanwhile, stationary engineer John Atkinson will sound mill whistle and town fire siren. In background is fire chief John Duguay.

Soft metal bar that melts quickly in heat is examined by day working foreman Lloyd Day and assistant superintendent Bob Engdahl at ink plant. When bar melts, cable releases and door shuts, confining fire.

vide secondary sources of supply.

Built-in, automatic sprinkling systems with strong water supplies are Marathon mainstays. They are recognized as the most reliable means to control fires in large industrial plants.

Exceptional Pacific Coast cloudbursts have poured 8 inches in an hour, but the deluge of water from an automatic sprinkler exceeds the heaviest recorded rainfalls in the United States.

An ordinary automatic sprinkler with 25 heads in operation delivers 12 inches an hour over the area. More than 40 gallons of water can be discharged from one head per minute.

Water, however, is not always an answer to fire extinguishing. In some Marathon areas, intricate systems using chemicals such as carbon dioxide are installed to control

Mobile pumper at Rothschild is kept ready to supply high-pressure stream of water at scene of any plant fire. Equipment receives one of regular checks by Ben Schaefer, chief of mill brigade; Dennis Gorski, Class C millwright, and Harold Anderson, Class A millwright.

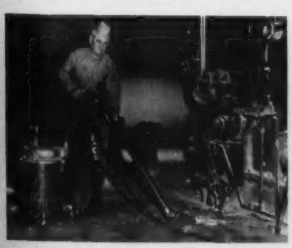
Electricity being a top cause of industrial fires, Marathon practices continual maintenance. At Menasha waxed paper plant, electrician, Walter Schmeisling installs high voltage wiring encased in metal conduit.

flammable liquids and chemicals.

With proper protective measures, these areas are made safer than the average home. In addition, hand fire extinguishers are located everywhere.

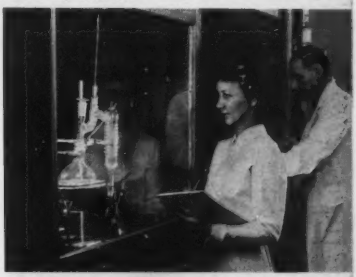
If there's a fire, sounding an alarm is of number one importance. Marathon has both manually operated and automatic alarm devices. Sprinklers have built-in features which indicate a fire's location on strategically placed fire alarm panels. Bells may clang a coded number of times. A public address system may be used. All manual and automatic systems tie in with, or are set up to relay to, fire stations.

Some of our plants are hooked up with central station fire alarm services. A watchman tour system records at the local telegraph office (1) regular reports made by company watchmen on their rounds and (2) a fire alarm for immedi-



Potential fires are averted if plants are kept clean. Janitor Joseph Belsky vacuums paper dust from rewinder area at Ashland.

Explosive gases are carried off as experiments are conducted in exhaust hoods at Rothschild's central research building. Senior technician, Nathalie Hickey and technician Vincent Richards conduct experiments.

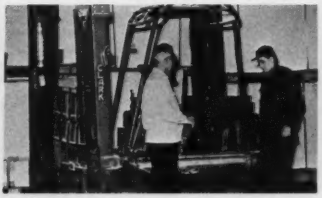


Continual change of air in research building's exhaust hoods is provided by a blower system which receives maintenance checkup by Curley Schulz, mechanic, and George Gease, service operations supervisor. This system can change the air in entire building nine times each hour, offering further protection from fire hazards.

Master fire alarm boxes must be reset promptly after being tripped so they'll be able to relay another alarm if necessary. At our Menominee plant, alarm box is reset by utilities engineer Ken Pape as Dan Homa, plant fire chief; foreman Will Guenther, plant fire captain; and Don Chevalier, building serviceman, watch operation.

Pouring thousands of gallons of water per minute on pulpwood piles at Marathon, Ont., these hoses are fed by network of steel pipes more than two miles long. Water must be kept at 175-pound pressure if there's a fire to force stream to tops of wood piles. Fire fighters man a high pressure line in background during drill.

Custodian Charles Tabaka and mechanic Curley Schulz test safety water showers for researchists who work with acids and burners.



If lift truck operator spots a fire, truck extinguisher can be used. At Oswego, shipping foreman Charles Gallagher and lift truck operator Bill Gomon discuss use.

Menasha wax refinery superintendent Walter Broas tests control which keeps wax from becoming overheated during the refining phase.

ate transmittal to the fire department.

Marathon plants are rated by insurance companies as having "superior protection." Newer plants have masonry or concrete walls, fire resistive windows, concrete floors, steel columns and roof supports, modern sprinkler and alarm systems, plus specialized protective devices for manufacturing areas.

In our older plants, there is intense effort to assure "superior protection." Sprinklers cover every nook and corner. Water supplies are made especially strong. Plenty of exits are provided. Modern fire alarms are installed to quickly alert everybody concerned.

Each plant has at least one man designated to coordinate fire protection efforts. All of the devices and methods, however, depend upon you, for employees have to be trained to maintain devices, to operate equipment and to respond to alarms. In that way, nothing is left to chance.

Menasha waxed paper plant fire training group is, rear, personnel supervisor John Jagerson; roll finishing foreman Elmer Kohler; shift foreman Gordon Weber; plant superintendent Bill Ritchie; front, superintendents Les Remmel, interfold, and Frank Staniak, waxing; plant protection supervisor Clarence Schroeder, instructor; and city fire chief Ed Heim.

Volunteer fire brigade members at Marathon, Ont., are, foreground, security guard Ray Veito; mill fire chief John Duguay; Len Veats; John Greene; Alex Cummings; Frank Baldwin and Ian Gillespie. Mill fire inspector Wallace Harrington is at wheel. On truck are Adolph Waver; Bob Johnston; Lloyd Brett; J. Barry Tyler and Jack Manson.

Central station fire alarm services are part of protection program at Green Bay plant. Left, watchman John DeGroot performs regular test of the system in plant. He turns key that transmits to telegraph office, which is manned 24 hours a day. There, technician J. W. Meyers watches tape come in. Tape tells where fire is and pinpoints location within plant. Meyers calls fire department. At No. 1 station house, operator Terry Wohlfeil takes call, sends trucks to scene. Another service aids watchman by recording his rounds. If he's not heard from on schedule, a man checks up to see what cause may be.

Fire Research – Part I

A Staff Report by Horatio Bond

Chief Engineer, National Fire Protection Association

Various organizations, almost all members of the National Fire Protection Association, are engaged in projects which come within the meaning of the term, "fire research." This report attempts to cover these activities.

The term, "fire research," means, of course, different things to different people. It has been used to roughly describe a great many activities, not all of which are pure research. One class of work outside the scope of pure research is product development, in which a manufacturer has to make various studies and tests in order to bring a product within the desired limits of performance or fire safety. There is also the examination and test of devices and systems for conformance with the performance requirements of the various codes and regulations of the National Fire Protection Association and other bodies. Another involves the fire testing of structural assemblies, for fire resistance, surface spread of flame or other factors. Finally, there are a great many investigations of all sorts which may not exactly fall in any one of these three categories.

NFPA Committee Activity

The Board of Directors of the National Fire Protection Association has a Fire Research Committee advisory to the Board. Its assignment is "To promote research in fire prevention and fire protection, encourage the interchange of information between research organizations, advise NFPA technical committees and others on request as to research projects, and to report to the Association on such activities." The members of the committee are John A. Neale, Chief Engineer, National Board of Fire Underwriters, Chairman; Nolan D. Mitchell, U. S. National Bureau of Standards, and N. J. Thompson, Director, Factory Mutual Laboratories. The committee has authorized the preparation of this staff report to show in some suitable form the extent and kind of fire research now going on and the facilities available for it.

Post War Activity

The effect of World War II and its aftermath in creation of weapons capable of fire destruction on a grand scale has prompted more than usual interest on the part of military and civil defense agencies in the general subject of fires and possible protective measures.

For example in May, 1955, at the request of the Federal Civil Defense Administration, the U. S. National Academy of Sciences-National Research Council organization in Washington held a one day Exploratory Conference on "Mass Fire" and "Fire Storm" Research. This conference narrowed down a bit the range of interest, agreeing that research should be on fires, small and large, with no restriction to "mass fires" or "fire storms." There was discussion of how far work in identification of the fundamental laws of nature involved in the origin and spread of fire should go, a preliminary conclusion being that it should not invade the fields of fundamental research on the chemical kinetics of combustion already covered by other groups, except when evidence exists that such research may throw light on the prob-

lems of uncontrolled combustion. As a result of the conference, the U. S. Federal Civil Defense authorities expect to make some arrangement with the National Academy of Sciences-National Research Council through its Division of Engineering and Industrial Research in Washington to perform coordinating functions for civil defense fire research work.

This Survey

The response which has been received from private fire research organizations and government agencies for information for the purpose of this report has been enthusiastic and helpful. A very large body of information has been collected and a full report will eventually be prepared about the facilities and procedures of all important agencies now doing research work in the fire field or in a position to do it. The selection of individual laboratories and organizations to be covered in this, a first installment, was made from those on which the collection of data was complete in time for this issue. Inclusion of a report in this installment does not imply a judgment that these are the most important.

Research Agencies Reported in Fire Research — Part I*

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American Gas Association Laboratories

Edwin L. Hall, Director
1032 East 62nd St., Cleveland 3, Ohio
1425 Grande Vista Ave., Los Angeles 23, California

The American Gas Association Laboratories is operated by the Association to pass on the safety, efficiency and operating durability of gas appliances.

As early as 1903, certain large gas utilities which had adequate laboratory and engineering facilities gave attention to features of gas appliance design and installation which had significance because of fire and other hazards. Uniform installation standards date from about 1913. In that year the Committee on Explosives and Combustibles of the National Fire Protection Association prepared a standard on gas shut-off valves and in 1914 it reported to the annual meeting a draft of

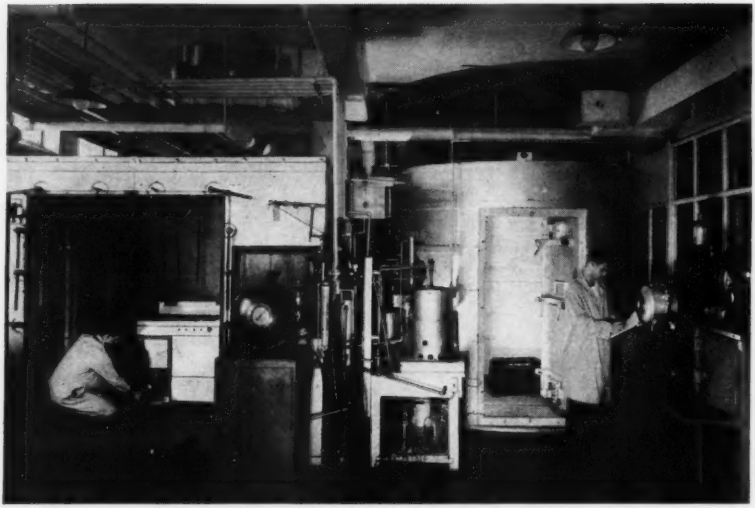
*Other research agencies, including the Factory Mutual Laboratories, will be covered in a future installment.

Warm air furnaces under test at the American Gas Association Laboratories at Cleveland. Heating element temperatures are being measured.

a National Gas Code prepared under auspices of the U. S. National Bureau of Standards in which the National Fire Protection Association, the American Gas Institute and other bodies had participated. This code is now entitled "Standards for the Installation of Gas Piping and Gas Appliances in Buildings" and is published by the American Gas Association, as well as by the National Fire Protection Association and the National Board of Fire Underwriters. The gas industry established in 1925 the American Gas Association Laboratories as an agency to supplement the installation standards with a program for testing, inspecting and labeling gas appliances.

With the cooperation of other trade and technical societies, notably the Gas Appliance Manufacturers Association, the American Gas Association has prepared in addition, two general sets of standards: Approvals Requirements (applying to self-contained appliances such as ranges and water heaters) and Listing Requirements (for accessories such as burner valves, thermostats and other controls). A list of these standards may be obtained from the American Gas Association, Inc., 420 Lexington Ave., New York 17, N. Y., or from the AGA Laboratories whose work is directed toward compliance with these standards. The standards are prepared under procedure of the American Standards Association and designated "American Standard."

Approvals and listings are reviewed at least annually and complete tests and rechecks of appliances are made at least every five years. The laboratory exami-



Closed rooms and auxiliary equipment for combustion tests of room heaters at American Gas Association Laboratories at Cleveland. In the room shown at left a combination range and room heater is mounted for test.

nations are supplemented by checking appliances in factories, sales rooms and homes. The Laboratories publish a Directory of Approved Gas Appliances and Listed Accessories. This is issued semi-annually, with monthly supplements, and may be purchased by subscription. The list enables identification of equipment by manufacturers, distributors, jobbers and dealers, according to the type of gas (natural or manufactured gas, liquefied petroleum gas, butane-air gas, propane gas) and according to approval for use at high altitudes.

The Cleveland laboratory currently has a staff of over 170 of whom a substantial number are engineers experienced in gas and gas appliance technology. Under an affiliated agreement with the Canadian Gas Association the Laboratories have, since 1927, also served as the official testing and approval agency for that Association. A Pacific Coast branch laboratory was established in 1931 and both the Cleveland and Los Angeles plants involve buildings with substantial floor space occupied by apparatus for technical testing and related research. In carrying out tests the Laboratories use apparatus to supply at least six types of test gas and a constant program is carried out to make sure that these gases are actually representative of those used in American and Canadian territory. A recent investigation, for example, was made of liquefied petroleum gas-air test gases.

Gas appliances must actually operate without causing excessive temperatures on adjacent woodwork or walls, must produce no incompletely burned combustion products, must not leak gas and must be so constructed that in normal use no danger will exist of cutting hands on sharp exposed edges or of contracting burns from control handles or other surfaces normally exposed to manual contact. In recent years, an increasing number of gas furnaces and boilers for house heating have been developed for installation in closets and enclosed spaces. This has required attention not only to the possible ignition of combustible woodwork but also to air for combustion and to venting.

California State Fire Marshal Laboratory

Joe R. Yockers, State Fire Marshal
1102 South Grand St., Los Angeles, California

The Laboratory of the California State Fire Marshal was originally established to conduct research and tests in the development and approval of flame-retardant treatment processes. It has been expanded in connection with the flammability of textiles and, beginning in 1956 for the classification and labeling of fireworks. Regular work is also done in connection with flammable liquids, chemicals and building materials. A specific application has been surgery safety problems, particularly electrical conductive flooring and other equipment for hospital operating rooms.

A List of Approved Flame-Retardant Chemicals, Processors and Inherently Nonflammable Decorative Materials is published annually. The current report is a 38-page list obtainable from the California Printing Division, Document Section, Sacramento 14, California, at a cost of 50 cents per copy, plus 3 percent sales tax.

During the past year the laboratory has done research on textile flammability, flame-resistant processes for decorative material for Christmas trees, studies in connection with the development of fire-resistant corrugated paper board, and studies on methods of supporting vinyl plastic ceiling lighting materials.

Columbia University in the City of New York

New York 27, New York

As an important research center, the University has, from time to time, done work in the fire field. Of historical importance, for example, the Civil Engineering Department, now headed by Professor William J. Krefeld, contributed to the early development of techniques for the testing of structural components of buildings. However, this phase of activity has been subsequently transferred to commercial laboratories for routine testing using equipment which was developed as a result of early researches of this department under Professor Ira H. Woolson.

The Chemical Engineering Department has been engaged for over ten years in studies sponsored by the Quartermaster Corps of the U. S. Army, concerned with principles and methods for the retardation of the combustibility and flammability of textiles and clothing. Professor James M. Church, of the Chemical Engineering Department, serves personally as a member of the Committee on Wearing Apparel of the National Fire Protection Association and has made available to it the results of these extensive researches.

Francis Earle Laboratories, Inc.

L. M. Greenstein, President
1057 Lower South Street, Peekskill, New York

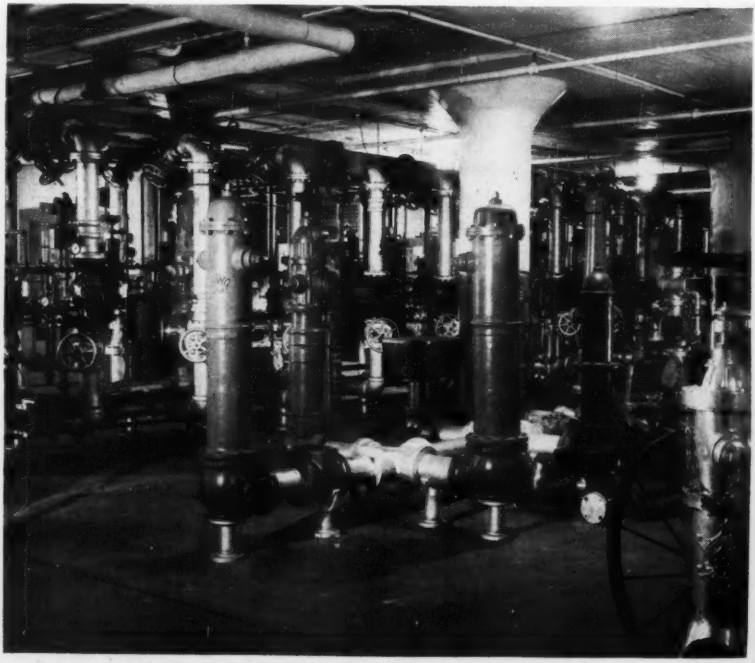
This laboratory is a commercial research laboratory with three important areas of work, crystal and pigment chemistry, synthesis of biochemicals, and fire extinguishing research. Background and experience in the latter field were obtained primarily in projects with The Mearl Corporation, manufacturers of mechanical foam liquids. The laboratories embrace 750 square feet and about a quarter of an acre of yard space for this particular research; four professionals and six other staff are engaged in fire research activities. A study of magnesium fire extinguishing agents is currently in process.

Factory Insurance Association

Frank D. Ross, Manager, W. H. Forristall, Assistant Manager
555 Asylum St., Hartford 2, Connecticut

This is an association of over 100 capital stock fire insurance companies in the United States, organized to assist fire insurance agents and brokers to serve policyholders which are, for the most part, owners of some of the largest industrial properties of the United States. It has a large professional and business staff at the headquarters at Hartford and at 19 field offices their work is supplemented by a considerable force of field inspectors located at the principal industrial centers of the United States to give engineering advice to their assureds.

The F.I.A.'s principal research activities are under the direction of L. B. Hansen, Superintendent of Engineering and Inspection, H. E. Muir, Research Engineer, and S. K. Goodwin, Special Engineer, at Hartford. The Engineering and Inspection Department embraces the work of the nation-wide engineering field staff, and includes fire loss analysis and engineering research work. There is an Engineering Council made up of senior engineers and there is a Fire Safety Laboratory for training and research.



In the Fire Safety Laboratory of the Factory Insurance Association at Hartford, Connecticut, there is probably the most complete collection of fire protection devices and equipment, including automatic sprinkler equipment, valves, hydrants, pumps, electrical fire alarm and supervisory equipment and industrial furnace control equipment.

Fire research facilities include equipment for determining explosion pressures produced by the ignition of combustible dusts suspended in air and for demonstrating the explosive characteristics of hazardous vapor-air and gas-air mixtures. Equipment also includes devices for accurately determining flash points and ignition temperatures of flammable liquids and there are combustible gas analyzers and related equipment.

The Fire Safety Laboratory occupies an entire floor of one building, in which space there is probably the most complete single collection of fire protection devices and equipment, including automatic sprinkler equipment, valves, hydrants, pumps, electrical fire alarm and supervisory equipment, and industrial furnace control equipment. The Fire Safety Laboratory has a full-time professional staff of four and it is used to supplement the research and engineering inspection work of the Association by providing training and information for staff men and plant protection personnel of policyholders with respect to types of fire protection devices and their installation, operation and maintenance.

Regular activities include:

The issuance to policyholders of loss preventive studies.

Publications from the Engineering Council on recommended good practices with respect to industrial fire hazards and protection equipment.

Engineering research on problems submitted by policyholders involving industrial processes and protection.

The operation of one-week and four-week training courses for the Association's own field men, for plant protection personnel associated with industrial plants which are FIA policyholders, for members of public fire departments and others.

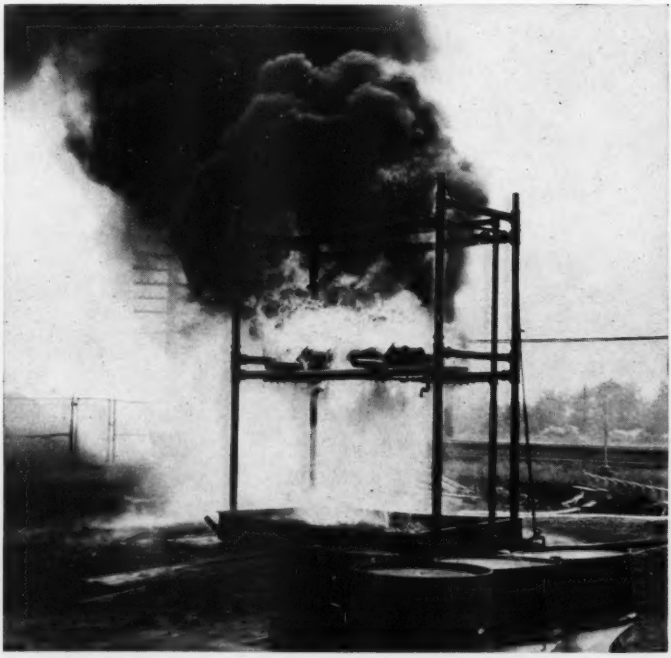
Laboratory yard at Grinnell Corporation plant at Cranston, Rhode Island. Office building in foreground, test building beyond. The test building is smaller, but similar in instrumentation and arrangement to the test building of the Factory Mutual Laboratories at Norwood.

Grinnell Research and Development Division

Ira W. Knight, Manager, A. J. Loepsinger, Director of Research
Providence 1, Rhode Island

Research activities include development of products, specifications for installation and use, studies of newly developed hazardous materials and processes, and the proper methods and materials for fire detection and control; also services for other divisions of company involving such matters as construction and installation of industrial power piping, pipe suspension, industrial humidification and heating. The Research and Development Division includes a staff of approximately 75, of whom 30 are professional, and has three buildings totalling approximately 35,000 square feet of floor space at Providence and a two-acre test area with test buildings at Cranston, R. I.

The Providence facilities include a metallurgical division, which has for its major equipment two Bausch and Lomb research metallographs, three Rockwell hardness testers, five polishing heads and other equipment. Other facilities at Providence include equipment for standardized fuming tests and salt atmosphere corrosion tests, two controlled atmosphere automatically controlled electrically heated ovens, a rubber mill, presses and ovens for development work on rubbers and synthetics for diaphragms and gaskets, high pressure pumps, tanks and equipment for strength and friction loss tests on hydraulic fittings, power driven equipment for the ready determination of



Mock-up by which lubricating oil may drip on hot pipes to test water spray apparatus on resulting fire, one item of special apparatus at Grinnell Corporation laboratory yard at Cranston, Rhode Island.

sprinkler distribution characteristics. Pure research has included a study of the phenomena of combustion, and, in particular, the relation of vapor dilution to fire extinguishment. There are a model shop and other facilities for doing development work on various products, some important items of which are automatic sprinkler heads, valves, fittings, hangers and pipe suspension equipment, humidifiers and unit heaters.

The test facilities at Cranston provide the necessary open space, together with water supply and piping equipment, for outdoor tests of water spray systems for control of fire in transformers, on open tanks of flammable liquids, for tank protection against exposure fires, for fires in ruptured piping containing hazardous liquids, in saturating tanks and similar equipment. Facilities are also available for large scale tests using foam, foam-water spray, carbon dioxide gas and dry chemical. The facilities are often used for instruction in fighting fires.

There is also a building in which full scale operating tests of fire protection equipment including fire tests may be run. This building has a section 30 by 40 feet with a 26-foot ceiling and another section 40 by 40 feet with a 15-foot ceiling. The building has permanently installed thermocouples and complete recording equipment.

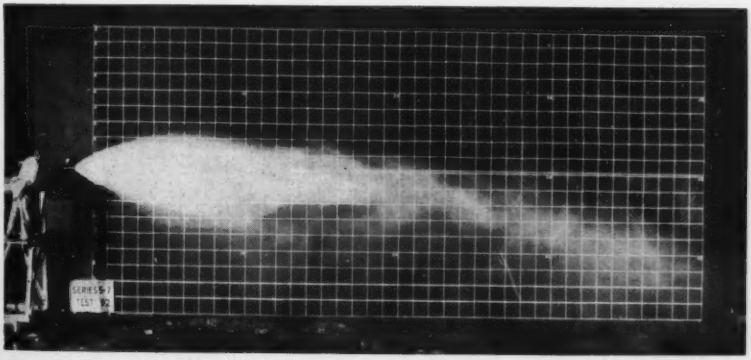
Improved Risk Mutuals

H. F. Russell, General Manager, P. E. Hubby, Chief Engineer
15 North Broadway, White Plains, New York

The Improved Risk Mutuals is an association of mutual fire insurance companies organized to provide engineering and technical service to this particular group of companies and to their policyholders.

At its headquarters, the Improved Risk Mutuals has laboratory service to which two professionals and four other staff give attention on a part-time basis. The laboratory is also used to give training to new technical men, particularly with respect to fire hazard problems and fire protection equipment.

Studies of a special nature are made for policyholders. Illustrative of these were studies made during 1954 on the fire hazard characteristics of leather finishes as employed by tanneries.



In the Maryland studies the discharge of each individual fog nozzle was recorded in photographs taken at night under stroboscopic lighting enabling "stop-action" shots in which actual water drops can be seen with a magnifying glass. This data provided accurate comparisons on the measured background, since all photos were taken with same camera, from same position, with same exposure and development.

View of test site at University of Maryland where fog nozzle studies were conducted in 1954. Robert C. Byrus, Director, Fire Service Extension Department of the University, who supervised the studies, is shown (left) with some of the camera and lighting equipment used in the studies.

University of Maryland Fire Service Extension
Robert C. Byrus, Director
College Park, Maryland

The Fire Service Extension Department is part of the College of Engineering and is financed by the State of Maryland primarily to carry on a program of fire service training, which includes fire prevention, fire protection and fire suppression. Its terms of reference are broad and the four professional staff members have engaged in experimentation and observation of fire behavior in actual burning structures.

The facilities of the Department consist of 25,000 square feet of modern building floor space and some 20 acres of yard space. Much of the building space is occupied by fire equipment, laboratories and classrooms. Equipment used by fire departments, automatic sprinkler, fire alarm, and related devices used in private fire protection are available both for demonstration and study.

Informal experimentation to cause fire drafts to move in a controlled direction has included study of the movement of air during fires by means of fire department fog nozzles.

During the past year, discharge studies at a range of pressures were made on practically every commercial fog or spray nozzle sold in the United States. This project was financed by a grant from the U. S. Department of Agriculture, Forest Service, and the U. S. Federal Civil Defense Agency. The results have been published by the National Fire Protection Association, whose Committee on Fire Department Equipment sponsored the work. See a reprint from FIREMEN magazine, September, 1955 (12 pages, $1.00) available from the Association.

Oklahoma Agricultural and Mechanical College

Professor R. J. Douglas, Head, Fire Protection Department
Stillwater, Oklahoma

Classroom and laboratory facilities are maintained in the School of Technical Training in connection with a 2-year course of instruction in industrial and municipal fire protection, and research work has occasionally been performed. For example, in 1949 an investigation was conducted in the Division of Engineering Research to determine if certain combustible solvents or solids when permitted to come in contact with an oxidizing agent would involve sufficient heat to cause ignition. The results were published in a paper entitled, "Some Studies in Chemical Fire Hazards", Publication No. 73, November, 1949, of the Oklahoma Engineering Experiment Station, Stillwater.

More recently some preliminary work was done on a research project entitled "Case Studies of Fires in Buildings" and which was carried far enough to show that additional funds would be necessary for it. No work is currently being done.

Southwest Research Institute

Calvin H. Yuill, Director, Fire Technology Section
8500 Culebra Road, San Antonio 6, Texas

The Southwest Research Institute, organized in 1947, is a charitable trust operating under charter from the State of Texas. It has 126 trustees, 15 of whom serve as a Board of Governors. Harold Vagtborg is President. Current work is financed by research contracts.

The Institute has a sizable plant located on the 4000-acre Essar Ranch. Some 200 acres are currently in use, together with about 100,000 square feet of space in buildings. The staff includes 328 professional and 147 non-professional persons.

Fields of specialization are chemistry and chemical engineering, physics, engineering mechanics, engines-fuels-lubricants, economic geology and industrial economics. While Fire Technology is a function within the Engineering Mechanics Department, close cooperation with other departments provides a wide range of facilities and skills available for fire research.

Examples of research tasks with fire significance include work on cotton fires, static electricity, ignition of high energy propellants, and improving fire retardant properties of building insulation. During the last year an investigation of fire extinguishing agents for magnesium fires was completed. Current work includes a survey of the petroleum industry with respect to use of fire detection devices and an investigation of techniques for detecting explosive concentrations of vapors.

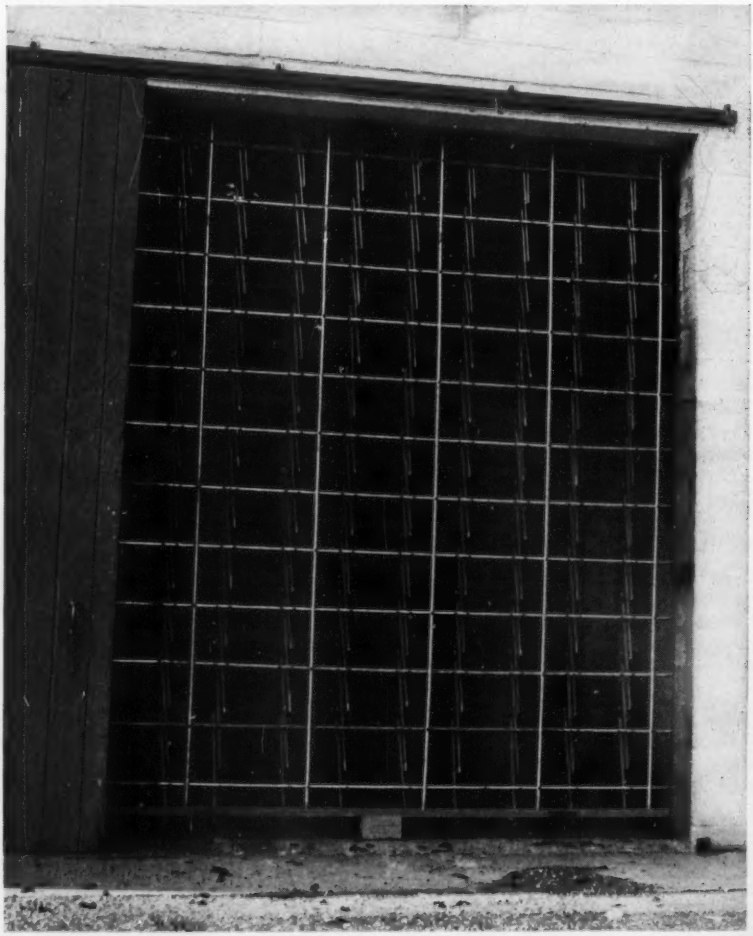
Stanford Research Institute

Stanford, California

Stanford Research Institute does contract research in the physical sciences, engineering and economics. The Institute is a Public Service Corporation chartered by the State of California and is associated with Leland Stanford Junior University, through its Board of Directors. There is no operational connection between the

University and the Institute. Practically all of the large industrial operations of the west coast are represented in its Board of Directors of thirty-seven. J. E. Hobson is Director.

While devoted largely to interests of the western states, it offers its research services to a wide area, enjoying substantial eastern and international support. The physical plant of the Institute occupies approximately four acres, with a staff of over 1,100 in the broad fields of physical sciences, engineering, and economics research.



Water distribution in a plane vertical to the direction of the discharge of each fog nozzle was measured at Maryland with the apparatus shown. It consists of glass tubes, the openings of which were located one foot apart in a doorway through which nozzle could be directed. The distribution was taken in a plane 6 feet from small nozzles and 12 feet from large ones.

Test Code:8-5

	1	2	3	4	5	6	7	8	9	10	11	12
A												
B						1	7					
C					7	65	28					
D			2	56	50	154	14	10	2			
E			3	66	94	99	47	139	66	8		
F		1	11	82	179	105	95	138	102	18	3	
G		49	68	98	97	80	62	116	140	86	4	1
H	1	16	72	81	64	134	70	88	108	101	40	2
I	1	5	20	73	121	74	92	83	82	35	21	3
J	1	3	9	41	66	54	98	73	61	12	5	2
K		2	3	9	9	42	70	26	17	6	2	1
L		1	2	3	4	22	28	13	5	3	1	

Apparatus used in University of Maryland fog nozzle tests which recorded relative amounts of water reaching each square foot in a plane vertical to the fog nozzle discharge produced data which could be plotted in a diagram like the above for each nozzle tested. Circles were drawn around the figures recorded for certain squares, beginning with that receiving the most water, and including all other circles where the amount received was 50 per cent of the first, or larger. This showed poor discharge patterns for many. This was one of the best patterns.

The Chemistry Department of the Physical Sciences Division has undertaken two projects bearing directly on fire research, one concerned with an evaluation of a new type of furnace vent pipe and the second, a study of in-transit fires in cotton bales.

The Combustion Physics Group has expressed interest in making studies on the microscopic level in which one inquires as to the processes in which fire is extinguished. This group is also in a position to undertake microscopic studies of the role of hydrodynamics and heat transfer in propagating fires.

Past experience of people in the Physics Department and Poulter Explosion and High Pressure Laboratories includes study of ignition of gases, of liquid monopropellants and of heterogenous liquid-gas systems, detonation in gases and in liquids, recombination processes and rearrangement collisions in gases and thermal explosion of solids.

A combustion Research Laboratory includes optical gear for schlieren and direct observation, electronic equipment suitable for making observations on the microsecond scale, and pressure gages with high frequency response.

Underwriters' Laboratories, Inc.

C. R. Welborn, President

207 East Ohio Street, Chicago 11, Illinois
2550 Dundee Road, Box 247, Northbrook, Illinois
161 Sixth Avenue, New York 13, New York
1655 Scott Lane, Santa Clara, California

At the Columbian Exposition of 1893, not only were the increasing uses of electricity featured, but also its fire safety. Underwriters' Laboratories grew out of work done at that period by W. H. Merrill and other engineers of capital stock fire insurance companies assisting the growing electrical industry. Thus began a standardizing and testing operation which has grown to where Underwriters' Laboratories is the largest single organization and has the most extensive facilities for a broad program of standardizing and testing all sorts of equipment related to fire and other hazards.

Mr. Merrill started electrical testing work in a room of Station No. 1 of the Fire Insurance Patrol in Chicago which was operated by the Chicago Underwriters' Association. Later his activities served both the Chicago Underwriters' Association and The (Western) Union, an association of insurance companies operating throughout the midwest. His office was formally identified as "Underwriters' Laboratories" in 1900 and incorporated in 1901. Also, in 1901, the National Fire Protection Association appointed a Committee on Devices and Materials and the National Board of Fire Underwriters arranged to publish and promulgate this committee's findings. The National Board of Fire Underwriters had early supported the original testing work and in 1903 provided money for a building and for additional staff.

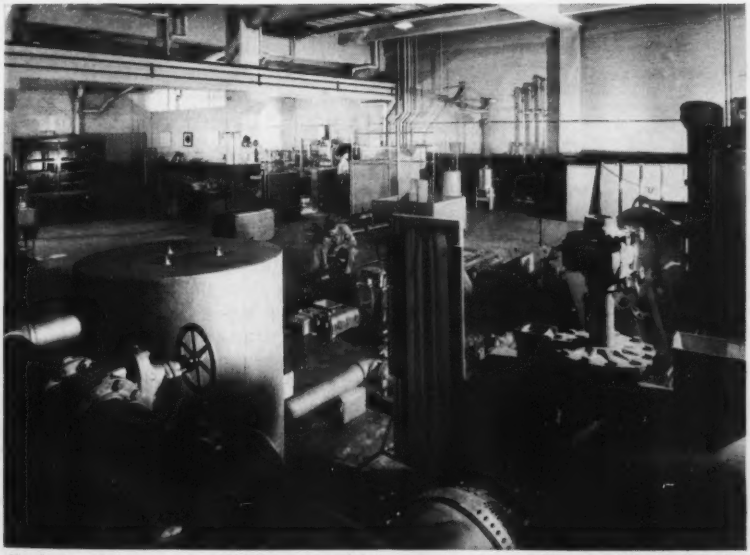
Traditionally, the work of the National Fire Protection Association and Underwriters' Laboratories has supported that of the other. Mr. Merrill was President of Underwriters' Laboratories, Inc., until his death in 1923. From 1903 to 1919, he was Secretary of the NFPA and served as the Sixth President from 1910 to 1912.

The National Board of Fire Underwriters originally sponsored Underwriters' Laboratories financially. Since 1917, Underwriters' Laboratories has been supported entirely by fees from industry which pays for specific services of testing and inspection of devices, systems and materials. Underwriters' Laboratories, Inc., is currently a business chartered under the laws of Delaware, the influence of the National Board of Fire Underwriters being principally reflected in its Board of Trustees.

For operation, its engineering is handled in eight Departments: Burglary Protection, Casualty and Automotive, Chemical, Electrical, Fire Protection, Gases and Oils, Inspection Control and Label Service. This engineering activity is supplemented by guidance from five Engineering Councils: Fire, Automotive, Casualty, Electrical and Burglary Protection, the members of which are principally managers, chief engineers, or building or electrical inspectors of fire insurance inspection and rating bureaus throughout the United States. These councils now perform much of the work which was done at the start by the Committee on Devices and Materials of the National Fire Protection Association. The scope of respective work of Underwriters' Laboratories and NFPA committees has crystallized to the point where NFPA does not deal with details of devices and materials which are best handled by Underwriters' Laboratories and other testing agencies. Practically all of the members of the Engineering Councils serve on committees of the NFPA dealing with related work, so that close cooperation is maintained.

Two paragraphs from the Laboratories' Certificate of Incorporation explaining the scope of its operations are as follows:

At the Santa Clara testing station of Underwriters' Laboratories, Inc., there is this laboratory equipped for making tests of electrical, fire detection, alarm and burglary protection equipment. There is a larger electrical laboratory at the New York station.



Explosion laboratory at Underwriters' Laboratories, Inc., Chicago. Certain of the equipment shown is used to test flame arresters and vent valves for flammable liquid storage tanks. In the background are facilities for making explosive gas-air mixtures which may also be used in testing explosion-proof electrical devices.

"By scientific investigation, study, experiments, and tests, to determine the relation of various materials, devices, constructions, and methods to life, fire, and casualty hazards, and to ascertain, define, and publish standards, classifications, and specifications for materials, devices, constructions, and methods affecting such hazards, and other information tending to reduce and prevent loss of life and property from fire, crime, and casualty.

"To contract with manufacturers and others for the examination, classification, testing, and inspection of buildings, materials, devices, and methods with reference to the life, fire, and casualty hazard appurtenant thereto or the use thereof; and to report and circulate the results of such examination, test, inspection, and classification to insurance organizations and other interested parties, and to the public, by the publication of lists and descriptions of such examined, tested, or inspected materials, devices, and products, by provision for the attachment of certificates or labels thereto, or in such other manner as from time to time may be deemed advisable."

An example of the fire hazard studies made on electrical equipment at Underwriters' Laboratories, Inc., Chicago, is this illustration taken during test of an electric motor in an atmosphere containing combustible dust.

Scope of UL Work

It is to be noted that the Laboratories are chartered to perform both fundamental research and by contract to perform standardization and testing functions for individual manufacturers and others. Space would not permit listing all of the industries served but among those for which the Laboratories does a large volume of work are the industries concerned with manufacture of fire equipment, electrical equipment, oil burners, roofing and other building materials, equipment for handling gases, oils and chemicals, safes and record containers, automobile and related equipment.

Underwriters' Laboratories, Inc., publishes annually lists of manufacturers whose products when tested have proved acceptable under appropriate standards and which are subjected to one of the forms of follow-up service provided by the Laboratories as a countercheck. These are:

ELECTRICAL EQUIPMENT LIST.

FIRE PROTECTION EQUIPMENT LIST.

GAS AND OIL EQUIPMENT LIST.

ACCIDENT, AUTOMOTIVE AND BURGLARY PROTECTION EQUIPMENT LISTS.

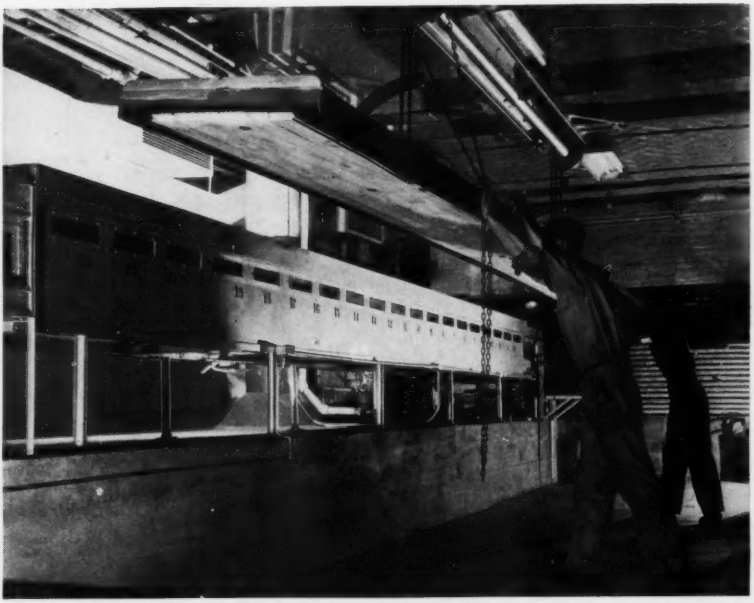
HAZARDOUS LOCATION ELECTRICAL EQUIPMENT LIST.

In addition, six issues of a Bi-Monthly Supplement to the above annual lists are published during the year. These listings, subject to appropriate recorded limitations for each of the categories, are affirmative. No negative findings or reports of criticisms are published, except to the submitter manufacturers. Estimates show that approximately 50 per cent of all original examinations disclose defective items of assembly or performance. Of these, possibly 50 per cent are resubmitted with improvements justifying "approval". The fees for this work are based upon the time spent in examinations, testing, and conference, according to payroll cost.

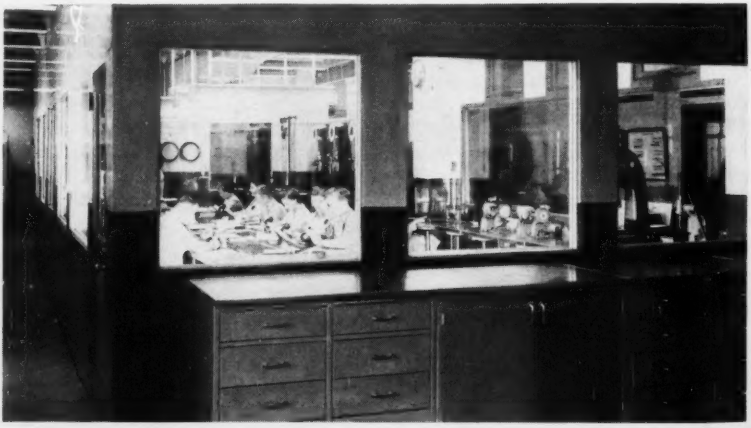
A wall furnace at Underwriters' Laboratories, Inc., Chicago. Wall assemblies and fire doors may be installed in front of this panel furnace to determine how long they can block and hold back the spread of flame.

Underwriters' Laboratories, Inc., follows up all listed materials at annual or more frequent intervals. The two principal means for identification of products also indicate the program for follow-up which is applied. Products that are subject to the annual Reexamination Service bear the manufacturer's name or trademark and a catalog number or similar individual symbol fully described in the Laboratories' publication. Symbols called "Reexamination Service Markers", to appear on name plates or on tags or containers under specified conditions, are employed in some cases to supplement the required means of identification of devices and materials listed under the Reexamination Service. Goods listed under the Label Service are reviewed by inspections at factories and are identifiable by means of stamps, transfers or tags attached to each unit of shipment or use. These labels have the name "Underwriters' Laboratories, Inc." on them, together with the word "Inspected" and other text to identify the classification of products bearing them. Most labels are serially numbered. Labels constitute reports by the inspectors of the Laboratories that devices bearing them conform to applicable standards. Reexamination Service markers are the manufacturers' assertion that goods are listed by Underwriters' Laboratories, Inc. Many purchasers and users and many authorities specify the Underwriters' manifest or label on all deliveries.

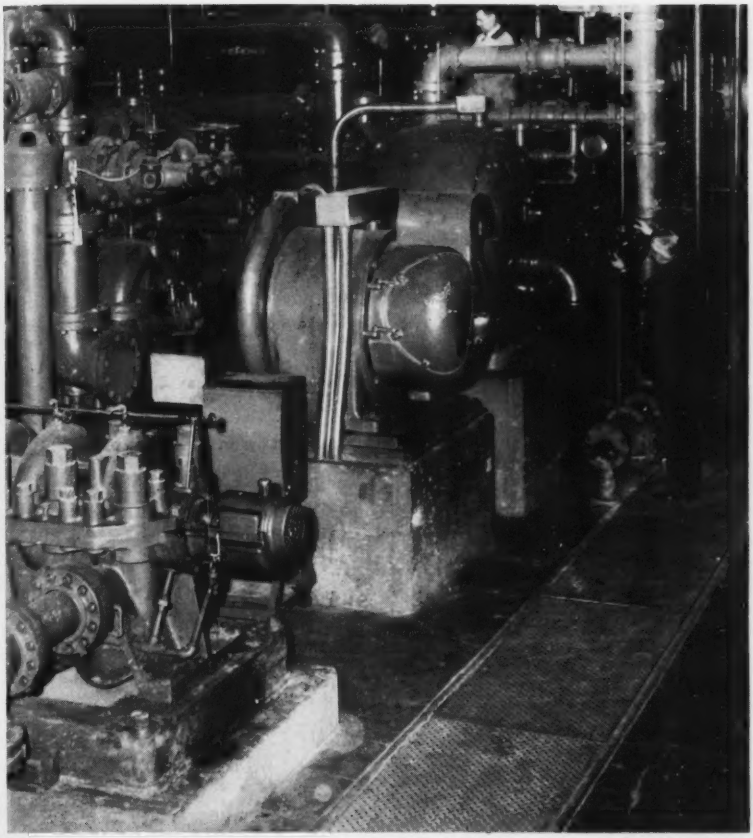
The listing or labeling of devices by Underwriters' Laboratories, Inc., is a great convenience to plant operators, architects, building owners and users in determining whether or not specific devices, systems and materials involve specific life and fire hazards or are factors in possible theft or accident. As a condition for the recognition of devices, systems and materials, the majority of insurance underwriters in the United



Underwriters' Laboratories, Inc., "tunnel" furnace at Chicago. Long samples of building materials may be installed as shown at the top of this horizontal furnace. Gas flames are projected against the far end of the test sample. During the test, spread of flame, temperature and smoke readings, and products of combustion samples are taken.



One of the many special laboratories at Underwriters' Laboratories, Inc., Chicago. In the one illustrated, temperature and humidity are controlled during physical tests of wire insulation, fire hose, and other rubber and rubber-like products.



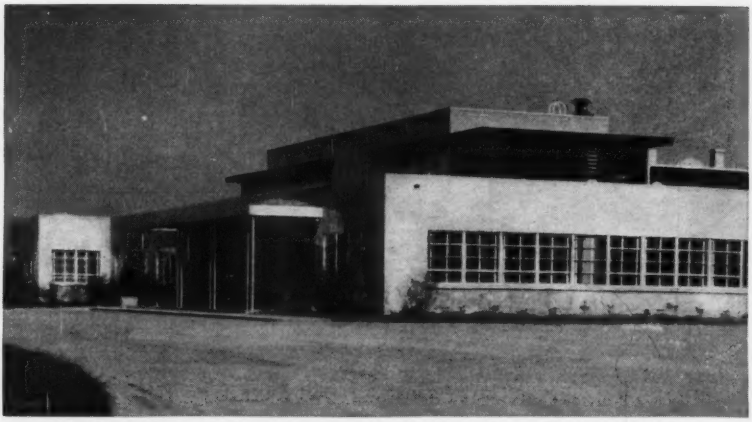
Underwriters' Laboratories, Inc., Chicago, has one of the most completely equipped hydraulic laboratories for examining automatic sprinklers and related fire protection equipment. In the foreground are shown three pumps used in developing the desired water pressures and flows for testing water supply equipment.

States rely on Underwriters' Laboratories' determinations and so do federal, state and municipal authorities.

UL Facilities

At the principal station of Underwriters' Laboratories there is approximately 140,000 square feet of floor space and nearly a half acre of yard space. The station staff includes 118 professional and 258 other personnel. At the Northbrook, Illinois, station the Laboratories have 153 acres which are being developed for the Laboratories' work. The buildings at Northbrook at present have approximately 30,000 square feet of floor space and 39 professionals and 47 other staff are there located.

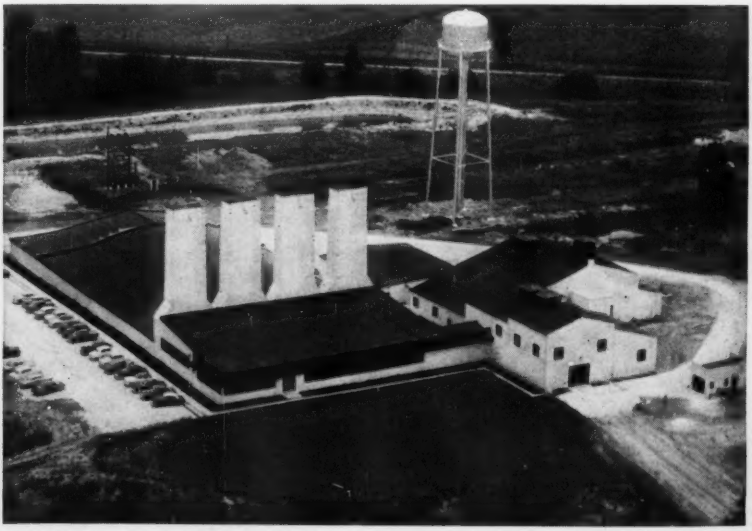
The New York station is a modern and adequately equipped laboratory for the examination and testing of electrical equipment and fire alarm and burglary signaling apparatus. M. M. Brandon, Vice President, is in charge. It has approximately 35,000 square feet of floor space with 60 professionals and 128 other staff personnel.



Underwriters' Laboratories, Inc., new station at Santa Clara, California.

The west coast station, formerly at San Francisco and now at Santa Clara, California, is equipped for the examination and tests of most electrical equipment and the products of some other classifications. This station is under the direction of J. A. MacNabb, Electrical Engineer, has six acres of yard space and approximately 30,000 square feet of building floor space with a regular staff of 18 professionals and 17 others.

In addition to these physical facilities, there are engineers at 172 field offices throughout the United States. The 1954 Annual Report of Underwriters' Labora-



Underwriters' Laboratories, Inc., buildings on its new 153-acre site at Northbrook, Illinois.

tories breaks down the total 809 full-time employees as follows: 4 officers, 273 engineers, 77 laboratory assistants, 162 inspectors, 55 plant men and 238 clerks, stenographers and other staff.

There is space in this summary only to note some of the more important facilities at the Chicago station of the Laboratories. There, however, will be found large furnaces for testing structural assemblies of building walls, floors or roofs, and columns, and special testing equipment for other details of building materials. Underwriters' Laboratories has a tunnel furnace in which spread of flame, temperature, and smoke readings and products of combustion samples may be taken during tests of wall and ceiling finish materials. There is elaborate electrical testing equipment, an explosion laboratory to test equipment designed to mitigate explosion hazards of flammable liquids and combustible gases, test facilities for automatic sprinklers, extinguishers and other fire protection equipment, including a large hydraulic laboratory for testing pumps, valves and other large size fire protection equipment. Other equipment provided is to test safes for resistance to tampering by burglars and to determine the degree of fire protection these containers provide for their contents.

The regular work of Underwriters' Laboratories may be briefly summarized by the statistic that approximately 12,000 investigations were conducted during 1954. Examples are specifications for a new classification for tool and torch-resistant safes, window-type room air conditioners, a 3,000-horsepower explosion-proof motor, magnesium X-ray tube heads, dry chemical extinguishing systems and trailer heaters fired by liquefied petroleum gas.

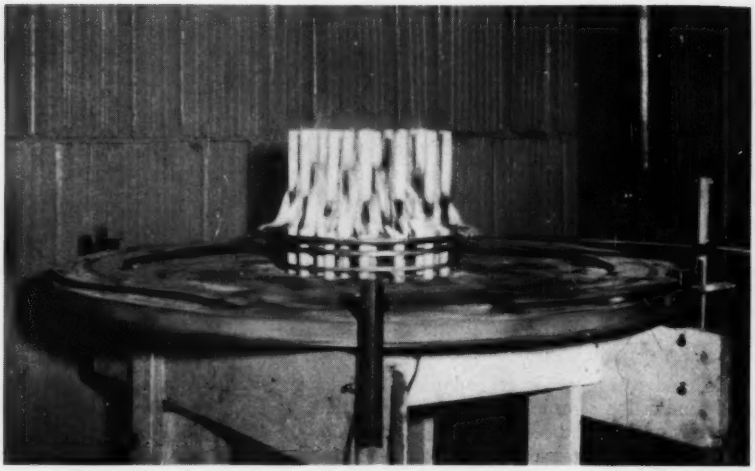
United States Department of Agriculture, Forest Service

R. E. McArdle, Chief, Forest Service
Washington 25, District of Columbia

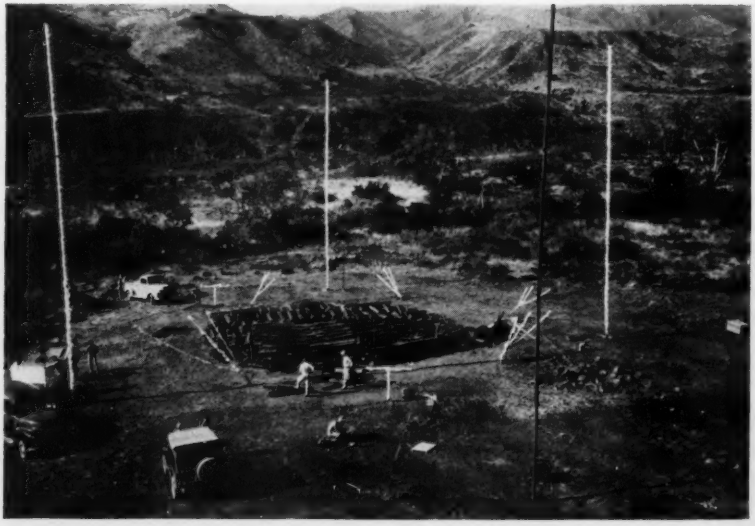
DIVISION OF FOREST FIRE RESEARCH, A. A. Brown, Chief, is part of Research Branch under V. L. Harper, Assistant Chief, Branch of Research, Forest Service, Washington 25, D. C. This division performs staff work for the Chief, Forest Service, and plans and administers over-all program of fire research at experiment stations, research centers, and experiment areas in the field. It is responsible for correlating plans and projects for related work undertaken at the Forest Products Laboratory.

DIVISION OF FIRE CONTROL. C. A. Gustafson is Chief, and Ira C. Funk, Equipment Development Specialist, of this Division. This Division is part of the Branch of National Forest Administration under Chief, Forest Service, Washington 25, D. C. Activities of this division include fire-fighting equipment development work. The chief centers in this development program are the Equipment Development Laboratory at Arcadia, California, under Eugene E. Silva, and an aerial research center at Missoula, Montana. These test centers provide facilities for testing pumps, all kinds of parachute gear and mechanical equipment. Equipment development work is reported in "Fire Control Notes," a quarterly periodical of the Forest Service, Superintendent of Documents, Washington 25, D. C. (Each issue 48 pages, 6 by 9 inches, 20 cents per copy; 75 cents a year.)

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION, 347 Forestry Building, University of California, Berkeley 1, California. Geo. M. Jemison is Director and R. Keith Arnold, Regional Chief, Division of Fire Research. A small fire research laboratory is maintained at Berkeley and a 1,600-square-foot building near the campus is being added to the fire research facilities. The regular fire research staff consists of five profes-



Pine dowels were treated with fire-retardant chemicals to find treatments which could be sprayed on brush. The dowels were subjected to a ring of gas flame on this "fire wheel" at the Berkeley fire laboratory in California and later the chemicals were tested on grass and brush fuels in actual fires at Camp Pendleton as a part of "Operation Firestop."



This shows the scale of some of the test work of "Operation Firestop." A heavy fuel concentration was set up in this, one of eleven fires set to study behavior of the fires and heat transfer.

"Operation Firestop" ran eleven fires, the scale of which this one illustrates. All were heavily instrumented to get accurate behavior data. This one was designed to produce a moving fire front in medium sage fuels.

sionals, plus a varying number of field assistants. A special defense project group which is working under sponsorship of the U. S. Department of Defense consists of eight professionals. The usual fire research work at the station includes studies in the effects of fire ignition and behavior due to variations in natural fuels, weather and topography. Recent fire research is summarized in the "Annual Report — 1954, Forest Research in California," issued by the station (72 pages, 8 by 10 inches).

"Operation Firestop" was a one-year activity in 1954 in which the California Forest and Range Experiment Station, the Arcadia Equipment Development Center and the California Regional Office, all agencies of the U. S. Forest Service, cooperated with other agencies in a large scale fire study. Other participants were four California State agencies, the Fire Marshal's Office, the Division of Forestry, University of California School of Forestry, and Office of Civil Defense, two fire departments, those of Los Angeles County and Los Angeles City, three other U. S. agencies, the Marine Corps Base, Camp Pendleton, California, the Federal Civil Defense Administration and the Weather Bureau, and the Pacific Intermountain Association of Fire Chiefs. Assistance was also received from other west coast military agencies, fire departments and industries. R. Keith Arnold, at that time professor of the School of Forestry, University of California, Berkeley, served as manager of "Operation Firestop."

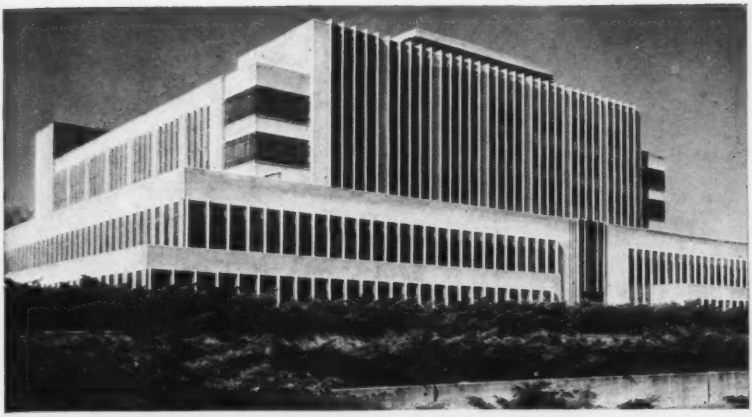
The California Division of Forestry and Los Angeles County Fire Department furnished considerable manpower and facilities additional to those of the Forest Service and at one time or another a large number of people were involved. The

"Helitanker," one of the contributions to aerial fire fighting developed by "Operation Firestop." Nine-place Sikorski S-55 helicopter is carrying a unit consisting of 100-gallon tank, small pump and 300 feet of lightweight hose.

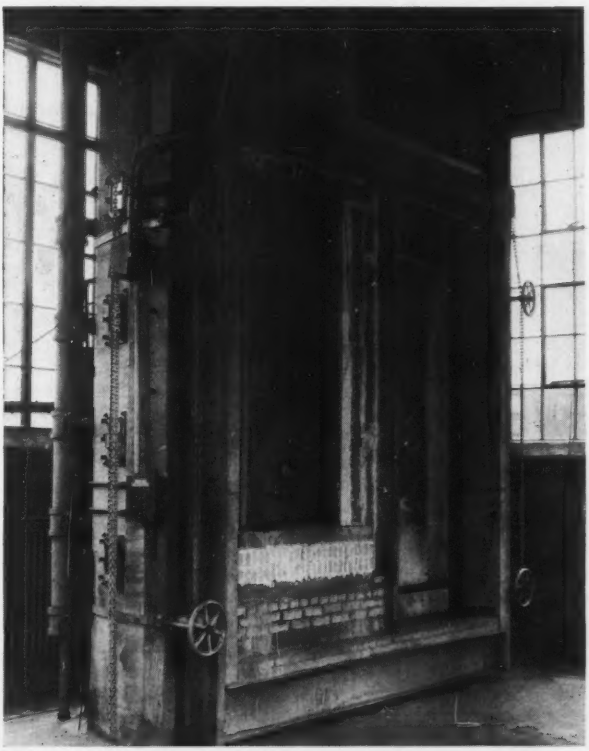
working group averaged 40 men during a three months' field program, July 1 to October 1. During this period, 200 test fires were started and 22 weather stations were operated. Fuel and climate measurements were made on all test fires. In addition, 11 fires were set to develop means of measuring heat transfer characteristics. Wind studies and temperature and humidity soundings were made, during fires, from ground level to 20,000 feet, twice a day. In addition to the fire behavior studies, studies were made of the use of fire retardants which can be sprayed in water solution on forest fuels, techniques to accelerate backfiring and operational studies of water application by aircraft and helicopter.

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION, 25th and Adams Avenue, Ogden, Utah, Reed W. Bailey, Director. Jack S. Barrows is Chief, Division of Fire Research at the associate research center at Missoula, Montana, where there is a staff of four professionals and office space and a small fire laboratory are maintained.

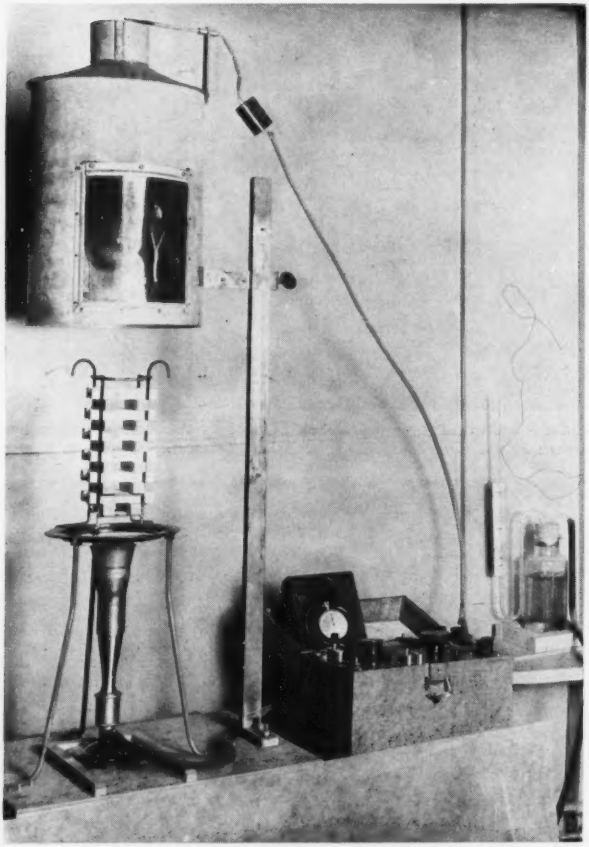
"Project Skyfire" was carried on during 1954 with the cooperation of the Munitalp Foundation, Inc. This is a program designed to acquire basic scientific information about lightning fires in the western forests, the atmospheric and cloud conditions which produce them, the nature of the local weather before, during, and



Forest Products Laboratory of the Forest Service of the United States Department of Agriculture at the University of Wisconsin, Madison.



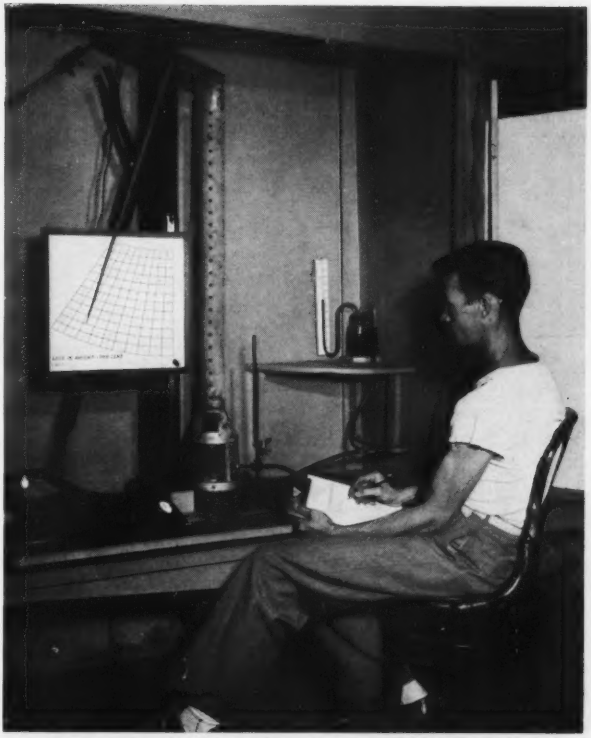
Wall furnace for fire-resistance tests at Forest Products Laboratory.



The crib test is used in determining effectiveness of flameproofing treatments of wood. Crib test apparatus of Forest Products Laboratory is shown. The test is described in Standard No. 254, National Fire Codes, Volume III, published by National Fire Protection Association.

after their occurrence, and the possibility of modifying lightning storms by cloud seeding. A cloud observation program at some 25 mountain summit observation stations included some at which special time-lapse movie cameras were installed to obtain typical cloud records. Pictures imply correlation between certain fast-moving altocumulus and cirrus clouds and the presence of the major axis of a jet stream and this in turn was shown to be related to the most serious of the lightning fire outbreaks. "Project Skyfire" is the subject of Research Paper No. 35, November 1954, published by the station (62 pages, 8 by 10 inches).

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION, 729 Northeast Oregon St., Portland 8, Oregon, Robert W. Cowlin, Director. The principal facilities utilized for forest fire research in this region are at the Wind River Experiment Station at

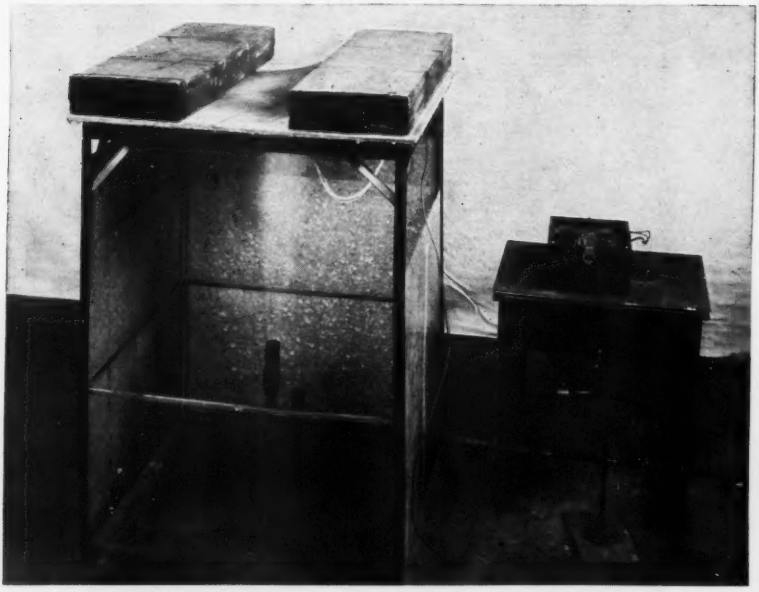


The fire-tube test was devised about 1928 at Forest Products Laboratory. It uses apparatus shown and has furnished information on fire-retardant chemicals in pressure-impregnated lumber. The test is described in Standard No. 253, National Fire Codes, Volume III, published by National Fire Protection Association.

Carson, Washington, which include a small laboratory with drying ovens and other equipment. Studies in this region are directed at hazard reduction in the heavy logging slash of the Douglas fir region and at the meteorological aspects of the fire problem in that area. There is a staff of two full-time professionals.

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, Colorado Agricultural and Mechanical College, Fort Collins, Colorado, Raymond Price, Director. One professional leader in forest fire research works with the Regional Administrative offices of the Forest Service at Denver, Colorado, and at Albuquerque, New Mexico, and with local state foresters on current fire problems.

LAKE STATES FOREST EXPERIMENT STATION, University of Minnesota, St. Paul 1, Minnesota, Murlyn B. Dickerman, Director. One professional member of the staff is assigned to forest fire research with laboratory facilities available through the University. The principal fire research activities having relation to fire danger ratings, fire damage and the economics of fire control activities.



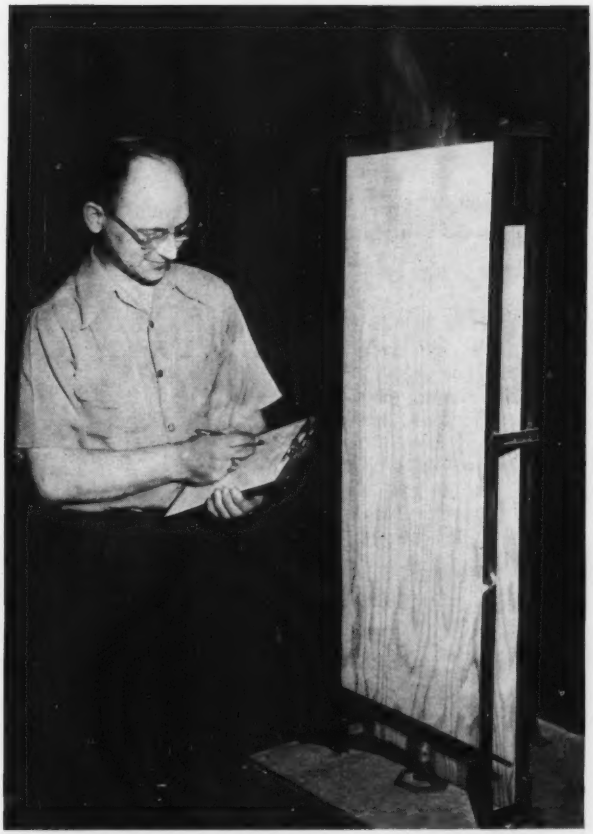
U. S. Federal Specification SS-A-118a for Prefabricated Acoustical Units described the test illustrated as a means of classifying combustibility of samples. Classification of such samples by this relatively crude apparatus is not as satisfactory as the use of a tunnel furnace, but it has had considerable use because it involves a simple assembly, the one illustrated being at Forest Products Laboratory.

CENTRAL STATES FOREST EXPERIMENT STATION, Old Federal Building, Columbus 15, Ohio, W. G. McGinnies, Director. There is no fire research man on the immediate staff of this station but a fire research project is being conducted at the Sinking Experimental Forest at Salem, Missouri, studying the effects of fire on soil and vegetation. One full-time project man is engaged in this work.

SOUTHEASTERN FOREST AND RANGE EXPERIMENT STATION, Federal Building, Asheville, North Carolina. Elwood L. Demmon is Director, and Ralph Nelson, Regional Chief of Fire Research Division. Laboratory facilities are provided at the Bent Creek Experimental Forest Station near Asheville, and four full-time men comprise the fire research staff. Fire danger rating work is done in cooperation with the Weather-Records center of the U. S. Weather Bureau at Asheville and at eight research centers. Recent studies have dealt with atmospheric conditions conducive to mass fires and to techniques of burning by which minimum damage to living trees may be caused.

SOUTHERN FOREST AND RANGE EXPERIMENT STATION, 2026 St. Charles Avenue, New Orleans 13, Louisiana, Philip A. Briegleb, Director. One full-time professional forest fire research man is maintained to head up work with state foresters and Forest Service fire control officers. Work has consisted of studies in fire behavior in southern pine and technics of controlled burning to accomplish certain benefits.

FOREST PRODUCTS LABORATORY, J. Alfred Hall, Director, North Walnut St., Madison 5, Wisconsin. The



A test useful in evaluating the effectiveness of fire-retarding coatings was developed in 1935 by Ragnar Schlyter at the State Testing Laboratory in Sweden. It uses two facing samples and the test involves the burning in the flue space thus formed as illustrated by this modified Schlyter apparatus at Forest Products Laboratory.

laboratory's work is devoted to wood utilization and operates in cooperation with the University of Wisconsin. It has three full-time technical staff men devoted to fire aspects of this research and about 2,200 square feet of floor space immediately assigned to their work.

Regular work of the laboratory has dealt with fire-retardant treatments for wood and methods of testing. The laboratory has facilities for many standard tests, the fire-tube test, the crib test, flame spread and fire resistance tests. The laboratory's facilities are described in its Bulletin No. 1443, December 1953, "Fire Test Methods Used in Research at the Forest Products Laboratory."

It has a fire-test house in which various floor, wall and ceiling finishes may be employed and in which complete burnout

tests are possible. Small-scale examinations have been made of the fire resistance of glue-laminated wood timbers.

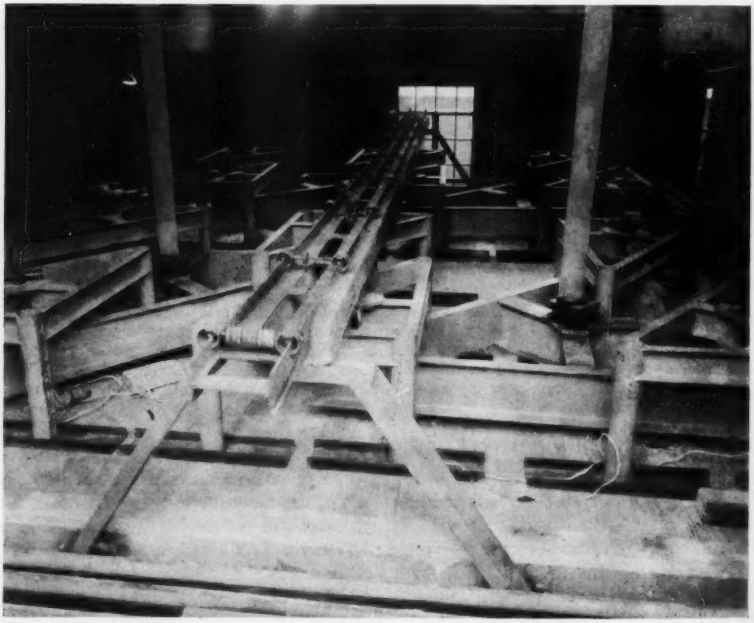
Current studies have covered the ignition of combustible materials by strong radiation and the fire resistance of wood doors. Work has been done to develop a tunnel furnace to measure flame spread, smoke developed and heat contributed with apparatus smaller than the Underwriters' Laboratories' tunnel furnace.

United States Department of Commerce
National Bureau of Standards, Fire Protection Section

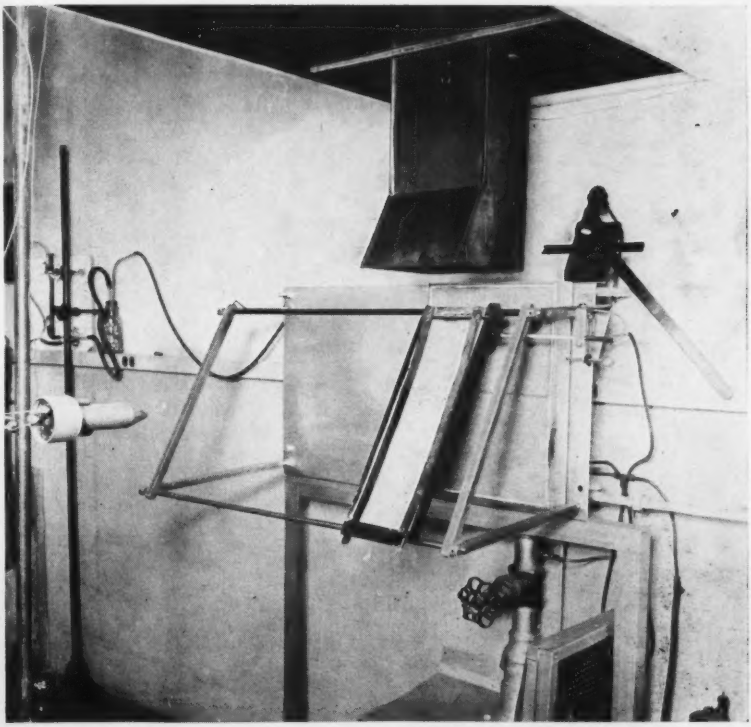
A. F. Robertson, Chief
Washington 25, District of Columbia

The National Bureau of Standards, A. V. Astin, Director, is a government laboratory. In addition to work authorized by regular appropriations it provides services for the various departments of the federal government, any one of which may transfer funds to the Bureau for special work. The Fire Protection section is part of the Building Technology Division, D. E. Parsons, Chief.

The Fire Protection Section has a staff of 17, of whom 11 are professionals. It has approximately 13,000 square feet of floor space and 6,000 square feet of yard space assigned to its particular activities.



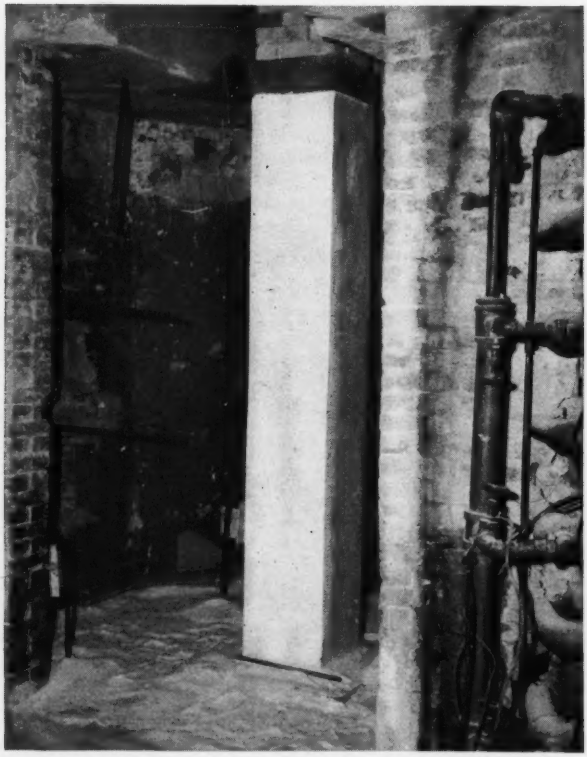
The U. S. National Bureau of Standards has furnaces for various tests of fire resistance of structural components and assemblies. There is a wall and panel furnace for specimens 10 feet by 16 feet and a floor furnace for specimens 13½ feet by 17½ feet. This shows the method by which a wood floor assemby, set up for fire testing, is loaded.



Radiant panel flame spread apparatus at U. S. National Bureau of Standards. This is just one of the many types of special apparatus at the Bureau's Fire Protection Section. Others include an inclined tunnel equipment for evaluating flame spread in roofing materials, vertical tube furnaces for measurements of combustibility of materials, equipment for measuring flammability of textile materials and spontaneous heating apparatus. This list could be expanded considerably. The Section also has the necessary ancillary equipment and facilities, recording and photographic equipment, humidity control apparatus, sample-conditioning ovens and rooms, and the like.

Regular work of the Fire Protection Section includes studies of causes of fires, including self-ignition phenomena, methods of fire detection and evaluation of performance of fire detection equipment, studies of performance of hand portable fire extinguishers and research on mechanism of fire extinguishment, studies of fire resistance behavior of various building constructions and theoretical research on behavior of specimens, studies of flame-spread test methods and evaluation of behavior of materials. The work on extinguishers is an example of work performed by way of assistance to other government agencies. One use of the Bureau's determinations on the performance of fire extinguishers is in connection with the approval of such units by the U. S. Coast Guard for use on merchant vessels and motorboats.

The National Bureau of Standards publishes a monthly Technical News Bulletin,



The U. S. National Bureau of Standards has a safe and column furnace which will take columns up to 13 feet in length. A column set up and loaded for test is shown. The furnace equipment includes master program control and temperature recording equipment.

approximately 16 pages, 8 by 10 inches. Papers resulting from the work of the Fire Protection Section published by the Bureau are listed in this monthly bulletin which is available for 10 cents per single copy or $1.00 a year, from the U. S. Superintendent of Documents, Washington 25, D. C.

Features of current work are reflected in papers issued during 1954. Some of the subjects covered were:

FIRE ENDURANCE OF OPEN-WEB STEEL-JOIST FLOORS WITH CONCRETE SLABS AND GYPSUM CEILINGS.

FIRE TESTS OF BRICK WALLS.

PRINCIPLES OF FIRE DETECTION IN AIRCRAFT ENGINE SPACES.

SELF-IGNITION TEMPERATURES OF COMBUSTIBLE LIQUIDS.

AN ADIABATIC FURNACE FOR THE STUDY OF SELF-HEATING OF POORLY CONDUCTING MATERIALS.

Special structure erected at U. S. National Bureau of Standards for a comprehensive study of chimney assemblies.

United States Naval Civil Engineering Research and Evaluation Laboratory

Construction Battalion Center, Port Hueneme, California

The Laboratory, set up on its present basis in 1950, is under the direction of the U. S. Navy Bureau of Yards and Docks and conducts research for the construction, operation and maintenance of the U. S. Naval Shore Establishment, including the Navy's Construction Battalions and advance bases overseas. V. G. Stevens, Commander (CEC) USN, is the current Officer in Charge. The position of civilian Technical Director is currently vacant.

The Laboratory has a main building of over 76,000 square feet, and other buildings. Approximately 27 acres of beach and land areas are also available.

Among the studies for which facilities are provided are those for research on structures and techniques of construction. Of these facilities, approximately 1,000 square feet of floor space and nearly an equal amount of yard space has been devoted to certain problems of fire research. These have been handled by the Evaluation Department's Heat and Sanitation Division, Stuart Giles, Director.

During 1954, and 1955 some tests were made of halogenated versus earth-metal salt extinguishing agents, and a portable packaged sprinkler system for fire protection of Arctic huts was developed. In November 1954, the Laboratory sponsored a three-day Fire Extinguishment Symposium (which was attended by military and civilian personnel) and they have published a report of the proceedings.

United States Navy, Material Laboratory

New York Naval Shipyard, Brooklyn 1, New York

The Material Laboratory developed from laboratory work for the Navy dating as far back as 1866, dealing with the testing of various materials and equipment delivered to the Naval Shipyard. Currently, it does research and development and assists the procurement programs of the Bureau of Ships. Captain A. B. Jones, Jr., is Director.

There is a Fire Extinguishment and Safety Equipment Section, in charge of Hyman Lacks, a materials engineer, in the Mechanics Branch of the Research and Technical Division. This section is engaged in development and evaluation work on fire-fighting equipment and materials. It has indoor hydraulic laboratories and other laboratory space totalling approximately 2,800 square feet and about 2½ acres of yard space at the Maspeth Annex of the New York Naval Shipyard. At the Maspeth Annex, tank and spill fires, up to twenty feet square, may be set outdoors. The section has a staff of five professionals.

Work has been done on mechanical foam-liquids, foam generating equipment, carbon dioxide systems, water sprinkler systems, vaporizing liquids, dry powder, chemical foam-powders, the extinguishment of alcohol, gasoline, rocket fuels and metal fires. Reports on work done by the section are generally for distribution within the armed services only. Evaluation reports of proprietary equipment and materials are also distributed to the manufacturers.

State of Washington Division of Forestry

L. T. Webster, Supervisor

Olympia, Washington

The Division of Forestry is part of the State Department of Conservation and Development. While no research agency is organized as such, the division is collecting its sixth year of data which, when analyzed, will be used as a guide in making modifications of a fire danger rating system initiated in 1950. Studies are also being conducted in spray applications for the control of roadside brush and the use of explosives for rapid fire trail construction. Two recent items of equipment development include a small pumping unit for pickup trucks and a combination dump truck and 10-ton lowboy trailer. A 980-gallon slipon tank is provided for the dump truck and the lowboy trailer is to haul a bulldozer.

Canadian National Research Council
Fire Research Section

G. W. Shorter, Head

Montreal Road Laboratories, Ottawa 2, Ontario

The National Research Council provides a government laboratory in which there is a Division of Building Research, R. F. Legget, Director, and of which the Fire Research Section is a part.

At the principal station, the Fire Research Section has approximately 2,200 square feet of building space and about a quarter of an acre of yard space immediately available for its work. There is a professional staff of five, plus four others. Regular activities of the section include field studies covering investigations at fires and studies of fire fatalities. Regular laboratory work has covered combustion

studies and the development and extinguishment of fire.

Representative topics studied or reported on in the past year included: deaths by fire in the Province of Ontario; investigation of fires; developing a test for determining the combustibility of building materials; a survey of existing test methods for classifying building materials as to their tendency to spread flame and work in the development of a new type of test; low-temperature ignition of combustible constructions; examination of certain materials to see if they were subject to spontaneous heating; measurement of the properties of mechanical foams under certain conditions; and the use of compressed air as an expellant for dry chemical extinguishers.

Canadian Standards Association, Approvals Division

G. M. Moes, Manager
Box 506, Weston, Toronto 15, Ontario

The Canadian Standards Association is chartered by the Canadian Federal Government and is financed by industry, including certain federal and provincial corporations. The Canadian Standards Association prepares some 300 standards, among them the Canadian Electrical Code and standards dealing with underground storage tanks for petroleum products and oil-burning equipments.

The laboratories of the Approvals Division test and report on electrical and oil-burning equipment for fire and electrical shock hazards. This approvals work is supplemented by field and factory inspections of equipment. There is a Montreal district office, W. Kofman, District Engineer, 515 DeMontigny Street East, Montreal, Quebec, a Vancouver district office, J. H. Radcliffe, District Engineer, 402 West Pender Street, Vancouver 3, British Columbia, and a European district office, B. W. S. Challans, District Engineer, 2 Park Street, London, W. 1, England. The Approvals Laboratories at Toronto cover over an acre and include 37 professional and 157 other staff and the field offices include three professional and four other staff.

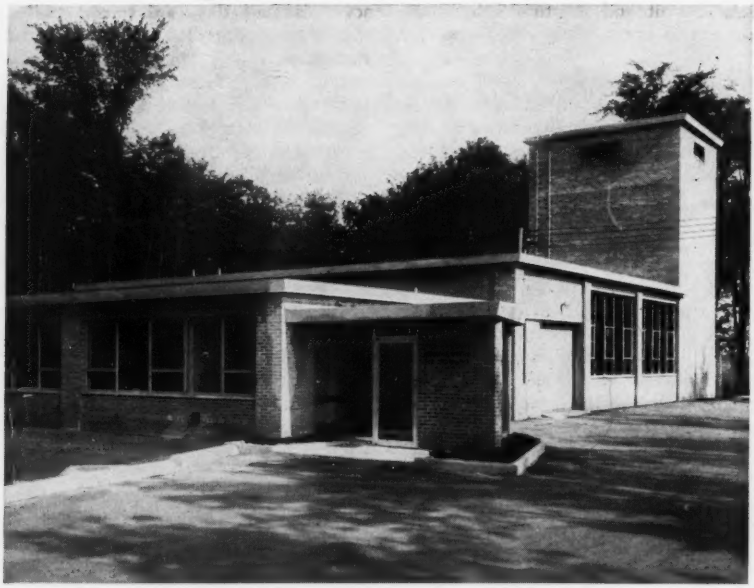
Standards on electrical equipment followed by the laboratories are enumerated in various Approvals Specifications, a list of which is available upon request. The fifth edition of a List of Electrical Equipment, approved by the Canadian Standards Association, was published in March 1955. This is a book of over 1,000 pages, distributed without charge to companies and persons properly concerned with the subject.

During the past year, a controlled-temperature and humidity room has been developed and is now in use for the testing of refrigeration and air-conditioning equipment. Two 125-volt DC generators of special design, driven by a single motor, have been installed for testing switches on gas-filled lamp loads. A fungus testing room is being completed for use in tests for non-metallic sheathed cable.

Underwriters' Laboratories of Canada

Edward F. Tabisz, General Manager
7 Crouse Rd., Scarborough, Ontario
Mail: Box 38, O'Connor Postal Station, Toronto 16, Ontario

Underwriters' Laboratories of Canada grew out of work by Underwriters' Laboratories of Chicago which as early as 1910 had included the testing, inspection



Station of Underwriters' Laboratories of Canada in Scarborough Township, Ontario, opened in 1954. It provides 8,800 square feet of working space in buildings and nearly four acres of yard space.

and labeling of several classes of equipment produced at Canadian factories. In 1920, Underwriters' Laboratories of Canada was incorporated under a Canadian Government charter but its operations continued under the sponsorship of the National Board of Fire Underwriters and the facilities of the Chicago organization were used. This arrangement served some of the immediate requirements of Canadian industrial and insurance interests but it did not provide in Canada the same broad service which Underwriters' Laboratories, Inc., of Chicago, provided in the United States.

Underwriters' Laboratories of Canada dates, as a completely Canadian organization, from December 2, 1949, when its sponsorship was transferred to the Dominion Board of Insurance Underwriters, an Association of some 180 joint-stock fire, casualty and automobile insurance companies operating in Canada. Underwriters' Laboratories of Canada currently has no financial or legal affiliation with Underwriters' Laboratories, Inc., of Chicago, but maintains close technical liaison with its United States counterpart.

At present, financial support is derived partly from the manufacturing industry through fees for engineering service and charges for factory inspection work and partly from capital contributed by the member companies of the Dominion Board of Insurance Underwriters. The contributed funds have been allocated principally for capital expenditures such as land, buildings, and plant equipment. Continuing direction of the Laboratories is by a Board of Directors whose members are officers of insurance companies and insurance associations affiliated with the Dominion Board.

The establishment of a testing station at Toronto was begun January 1, 1950.

On October 4, 1954, a new testing station in Scarborough Township, Ontario, was opened. Current staff of the Laboratories are 19 professionals and 19 others. A resident inspector is maintained also at Montreal and part-time inspectors are located in 23 other inspection centers in Canada. The Laboratories also have a representative in London, England.

Laboratory facilities at the present time include test equipment enabling investigations on most types of fire extinguishers, automatic sprinklers, fire hose, gasoline hose, flammable liquids, roofing materials, and flameproof coatings and paints. Boilers and other facilities have been installed for conducting tests on gas and oil burners, oil-burning stoves and furnaces, safety combustion controls for gas and oil-fired equipment, limit controls, oil-burner ignition transformers and miscellaneous other heating accessories.

Objectives and methods are closely patterned after those of the Chicago organization as regards development of standards, preparation of reports, printing and distribution of listing cards, and the operation of a factory inspection and label service program. Underwriters' Laboratories of Canada has currently only one engineering council, a Fire Council, as compared with the five of Underwriters' Laboratories, Inc. While the Fire Council numbers among its membership representatives of provincial insurance inspection and rating organizations, it also includes representatives of several Canadian Federal Government departments, including each of the military services and each of the provincial fire marshals.

The listings of Underwriters' Laboratories of Canada are published in a LIST OF INSPECTED APPLIANCES, EQUIPMENT AND MATERIALS, issued annually as of September 1 with a Supplement under date of March 1. The current List includes equipment falling under the following general classification:

Accident Hazard.

Automotive Equipment.

Burglary Equipment.

Electrical Equipment.

Electrical Equipment for Hazardous Locations.

Fire Protection.

Gas, Oil and Hazardous Liquid Appliances.

Liquids and Materials Classified as to Fire Hazard.

Representative topics studied or reported on in the past year include prefabricated flues, electric motors for hazardous locations, fire alarm equipment, gas and oil-fired heating units and fire extinguishers.

Flood and Fire

By Chester I. Babcock, Manager, Fire Record Department

The wind forces dropped rapidly as Hurricane Diane moved northward over the Carolinas and Virginia and by the time the storm had reached the Northeastern and New England States there was no threat of extensive wind-damage. What the storm lacked in wind fury, however, was more than compensated by destructive torrential rains. Flash floods overflowed rivers and ponds, burst dams, took hundreds of lives and caused more than $1,500,000,000 property damage.

Included among the thousands of damaged or completely wrecked buildings were three large industrial plants destroyed by fires because of the floods.

Magnesium Powder Plant, Putnam, Conn.

Putnam, Connecticut was probably the worst hit community. During most of August 19, the town was drenched by torrential rains and overrun by a flash flood that overflowed the banks of the Quinebaug River.

In the early stages of the flood the river waters flowed into the basement and first story of the unsprinklered five-story brick, wood-joisted building occupied by the Metal Sellers Corporation, a firm that ground magnesium into magnesium powder. In this form magnesium ignites readily and produces burning temperatures at 2500° F. or higher. Water or the other common extinguishing agents cannot extinguish magnesium powder fires and, in fact, may intensify the burning or cause violent explosions. For this reason the Magnesium Powder Dust Standards of the National Fire Protection Association* do not permit sprinkler protection in plants where magnesium powder constitutes the principal fire hazard.

Because of the flood waters no one was in the building or in the vicinity when the fire broke out, and consequently any statement on the cause is conjecture. It is thought probable, however, that the fire broke out when water reached the boilers, and was intensified on spreading to magnesium powder drums and bins. Fire, punctuated by explosions, rapidly involved the building and raged unchecked until there was nothing left to burn. From all information received it appears that no effort was made to control the fire. It could hardly have been otherwise since the burning plant was located in a sea of flood water and all available fire department personnel were engaged in rescuing marooned people.

During the fire, hundreds of burning drums of magnesium powder floated from the building into the river. Many of them exploded as they were carried along and in a few instances flaming debris tossed into the air by the explosion ignited buildings along the river. At one location where the drums passed over a dam and submerged, vio-

Wide World

Magnesium powder plant, Putnam, Connecticut. A river bank would hardly seem to be a prudent location for a plant producing magnesium powder. Water and other common extinguishing agents cannot extinguish magnesium powder fires and may intensify the burning or cause explosions. Such was the case when fire broke out in this flooded building. Burning drums of magnesium powder floated from the building and in many instances exploded and set fires to buildings downstream.

*NFPA No. 652, Code for Explosion and Fire Protection in Plants Producing or Handling Magnesium Powder or Dust. Available from the National Fire Protection Association, Boston, Mass.

lent explosions hurled the drums into the air. Roofs of buildings of a textile mill located adjacent to the dam were ignited. These roof fires were extinguished before doing extensive damage by employees using hand extinguishers and an employee bucket brigade.

Textile Mill, Mechanicsville, Conn.

In Mechanicsville, Conn., the French River started to rise dangerously on Thursday, August 18. Employees of the Uncas Printing and Finishing Company began moving cloth from the first story and storing it in tote boxes in every available space around equipment on the second story of the 4-story brick, plank-on-timber building. This work continued Friday morning until flood waters began to rise. During the day water almost reached the second story.

At 5:30 A.M. August 20 a neighbor, 300 feet from the plant and on high ground, saw smoke coming from the second story in the vicinity of a stair tower. The alarm was given but flood water prevented firemen from entering the building.

Although a moderate amount of smoke continued to come from windows during the morning, it is presumed that the sprinkler system, supplied by a 165,000 gallon open reser-

Woonsocket Call

Electrical appliance factory, Manville, R. I. This fire originated in a flood-damaged section where restoration of sprinkler protection awaited building repairs. Quickly developing into an intense fire in the unsprinklered damaged section the fire burst into communicating sprinklered sections where simultaneous operation of many sprinklers overtaxed the water supply.

Wide World

Textile mill, Mechanicsville, Conn. The flood had put the two fire pumps at this mill out of order, leaving a 165,000-gallon reservoir the only supply for sprinklers. When fire broke out in the congested second story during the flood, it was held in check until the reservoir went dry, then spread out of control.

voir 1600 feet from the plant and on a hill, was holding the fire in check in the second story. This opinion was based in part on the fact that the reservoir when checked at 10:00 A.M. was found half empty, although it must have been nearly full when the fire started due to the heavy rains of the past few days. The reservoir was the only supply for sprinklers since both fire pumps were under water. The one pumper company that was able to reach the mill (roads were practically impassable) tried to pump into the reservoir but lacked 600 feet of the 1600 feet of hose needed for this operation. Attempts to pump into the yard system had to be abandoned since the normally closed valve between the public main and the yard system was under several feet of water.

At noon three men were landed on the roof of the adjoining Putnam Finishing Company mill by a helicopter. It is reported that the helicopter was to have brought a portable pump on a second trip but apparently the helicopter's services were needed elsewhere since it did not return. The men made their way to the second story of the Uncas Printing and Finishing Company plant where fire was discovered. From the wet condition of the cloth in the second story it was evident that sprinklers had been operating. However, they were not discharging water while the three men were there. Apparently the reservoir had gone dry before their arrival. Efforts were made to assemble extinguishers but because of the increasing amount of smoke the men had to leave the building. They made their way to safety in a rowboat, with the help of a rope that had been stretched between the building and dry land.

About 2:00 P.M. the fire increased in intensity and thereafter was seen to spread rapidly throughout the undivided plant. Flames also went over or through a substandard fire wall and destroyed the 4-story building occupied by the Putnam Dyeing and Finishing Company. Sprinklers in this building were supplied by the same reservoir as the sprinklers in the Uncas Printing and Finishing Company plant. The total loss was in excess of $6,000,000.

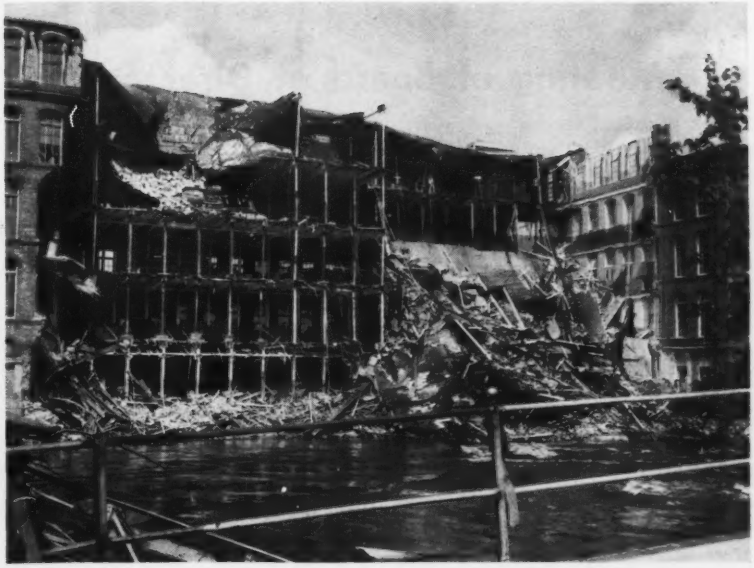
Electrical Appliances Plant, Manville, R. I.

A group of interconnected or slightly detached 1- to 5-story brick, plank-on-timber buildings with a ground floor area of approximately 215,000 square feet and total area of more than 535,000 square feet were destroyed by fire on September 12.

The buildings were formerly a textile mill, but at the time of the fire were occupied principally by the Royal Electric Company, Inc. for the manufacture and storage of Christmas tree lights, electric fuses and novelties. Small areas were used for storage of old textile machinery, noncombustible building insulation, and yarn. Except for a few detached wooden sheds all buildings were sprinklered.

Despite the fact that the fire broke out twenty-four days after the August flash flood associated with Hurricane Diane, the flood was responsible for its origin and spread. The Blackstone River flowed through the plant site, and on August 19-20 reached the third story level of a 900-ft.-long, 5-story building that extended along a bank of the river. The flood caused a 150-ft. section near the center of the exposed wall to collapse, and when the waters receded it was found that the five floors and the roof adjacent to the collapsed wall had sagged, sprinkler risers had broken, and large quantities of debris had been dumped into the building.

The flood had also snapped a 10-inch city main which normally constituted a good primary supply to sprinklers and yard hydrants. A week after the flood the snapped section had been replaced by 8-inch pipe, but the plant's



Woonsocket Call

Electrical appliance factory, Manville, R. I. Twenty-four days after flood waters caused this structural damage, fire broke out in debris in the third story. Since carpenters had not as yet shored up all floors and the roof, sprinkler protection in the section where the fire started had not been put back in service.

two 1500 gallon fire pumps had not been restored to service on September 12 because of flood damage to oil burning equipment and suction equipment. Sprinklers in the 5-story section adjacent to the collapsed wall had not been restored to service because of the sagging floors.

Sprinklers in small areas served by risers in the damaged area were also out of service, but otherwise sprinklers throughout the plant had been restored.

On September 12, carpenters were shoring up beams in the damaged section. They discovered fire in debris that the river had deposited in the third story. While one of the men ran to give the alarm, the others attacked the blaze with extinguishers. The fire spread rapidly, however, (witnesses report that the rapid spread was accompanied by a muffled explosion) and although response by the Manville and Cumberland Hill Fire Departments was prompt, all stories of the flood-damaged area were involved when the first fire company arrived. Since wind-driven flames were bursting into communicating sections the first concern of fire fighters was the safe evacuation of the 600 employees.

Simultaneous operation of large numbers of sprinklers in the communicating areas soon depleted the water supply. Fire then spread to adjoining sprinklered buildings through sprinklered combustible passageways and by means of wind-carried heat and embers.

Many small fires were started in dwellings and other buildings several hundred feet from the plant. These exposed buildings were saved and the main fire was brought under control by the combined action of thirty fire departments.

Meeting of Board of Directors

Boston, Mass. July 18, 1955

Present

Richard E. Vernor, Chairman
T. Seddon Duke, President
John A. Neale, Vice-President
Henry G. Thomas, Vice-President
Allen L. Cobb, Past President
Hovey T. Freeman, Secretary-Treasurer

Warren J. Baker	Leonard Peterson
Malcolm S. Blake	Elmer F. Reske
A. L. Brown	Geo. J. Richardson
E. Kenneth Clark	Roger H. Wingate
F. R. Fetherston	U. C. Young
A. Leslie Ham	

Percy Bugbee, General Manager; Charles S. Morgan, Assistant General Manager; Robert S. Moulton, Technical Secretary; Horatio Bond, Chief Engineer; George H. Tryon, Assistant Technical Secretary; M. M. Brandon, Chairman, Electrical Section.

Election of Officers

1. The following officers were elected in accordance with the recommendation of the Association in annual meeting: President — T. Seddon Duke; Vice-President — John A. Neale; Vice-President — Henry G. Thomas; Secretary-Treasurer — Hovey T. Freeman; Chairman, Board of Directors — Richard E. Vernor.

Committee Appointments

2. The Advisory Committee for 1955-1956 was appointed to consist of President Duke, Vice-President Neale, Vice-President Thomas, Secretary-Treasurer Freeman, and Board Chairman Richard E. Vernor.

3. Messrs. Malcolm S. Blake and E. Kenneth Clark were selected to complete the Nominating Committee for 1956.

Annual Meeting Plans

4. Plans for the 60th annual meeting in Boston, June 4-8, 1956, were discussed and the General Manager was authorized to proceed with the further development of the meeting plans. The previously established tentative schedule for holding the 1957 annual meeting in Los Angeles on May 20-24; the 1958 annual meeting in Chicago on May 19-23; and the 1959 annual meeting in New York on May 18-22 was continued and it was further voted to establish the following tentative schedule for additional meetings, subject to the completion of satisfactory arrangements for hotel facilities and other details — 1960 — Montreal; 1961 — Detroit; 1962 — Philadelphia.

5. The Program Committee for the 1956 annual meeting was appointed consisting of Richard E. Vernor, Chairman of the Board, T. Seddon Duke, President, and Percy Bugbee, General Manager, with power to add to their number.

Reports

6. The report of the Treasurer was accepted as presented by Hovey T. Freeman.

7. Reports on special projects were presented as follows:

Electrical Field Service and Editing the National Electrical Code — M. M. Brandon.

Flammable Liquids Field Service — Mr. Moulton, with discussion by Messrs. Baker and Cobb.

Gases Field Service — Messrs. Fetherston and Moulton.

Society of Fire Protection Engineers — Mr. Reske speaking as President of the Society.

Sparky-Advertising Council Project — Mr. Bugbee.

These reports were all accepted with approval of the policies therein indicated.

8. The budget as submitted to the meeting was amended in accordance with the recommendations of the Finance Committee and was approved.

Sparky's Fire Department

9. Mr. Bugbee reported on Sparky's Fire Department and the licensing program for Sparky products indicating very excellent response to the Sparky Fire Department program with enrollment of large numbers of children over a widespread area. He indicated that the licensing program for the use of Sparky's name on various projects is being increasingly successful and is beginning to bring in some income to the Association. The probability of additional future income from similar sources is anticipated. He stated that all income from this source would be allocated to the further development of the Sparky-Advertising Council Project. Mr. Bugbee also reported the termination of the contract with VIP, Inc. as agent for the Association in handling Sparky licensing and the execution of a new contract with Kagran Corporation to handle future licensing on behalf of the NFPA. This report was approved.

New Orleans Meeting

10. Mr. Moulton reported on plans for the 1955 regional meeting of the Association to be held in New Orleans November 28-30 with Louisiana State Fire Marshal Sidney S. Bowman as Chairman. The plans as outlined were approved and the staff was authorized to proceed accordingly.

Actions of the Board

11. Items referred to the Board by action of the Association at the 1955 annual meeting were acted upon as follows:

(a) Amendments to the Standards for Sprinkler Systems, NFPA No. 13, submitted by the Committee on Automatic Sprinklers, were adopted in the name of the Association in the form submitted with the agenda, subject to changes proposed by Board member A. L. Brown provided, however, that Mr. Brown's proposals for changes were to be submitted to the Chairman and Secretary of the Committee on Automatic Sprinklers for concurrence and if such concurrence should not be forthcoming the approval of Mr. Brown's proposals for changes by the Board is to be withdrawn and the Board action is to consist of adoption of the material in the form submitted by the committee without change. (The material acted upon consisting of one additional illustration, Figure 797, and explanatory tables at the end of the standard will be found incorporated in the 1955 edition of this text published in the National Fire Codes, 1955, and in separate pamphlet form.)

(b) Revisions in the Standards for the Installation and Operation of Centrifugal Fire Pumps, NFPA No. 20, were adopted in the form submitted to the Board with the agenda on recommendation of the Committee on Fire Pumps. (These changes are incorporated in the text printed in the National Fire Codes, 1955, and in separate pamphlet form.)

(c) The determination of policy on the 1955 minority report of the Committee on Motor Craft referred to the Board by action of the Association in annual meeting was discussed and referred to the General Committee on Marine Fire Protection for consideration and report back to the Board.

(d) Revisions in the Standards for Wetting Agents (No. 18) were adopted as submitted with the Board agenda on recommendation of the Committee on Wetting Agents. (The revised text appears in the National Fire Codes, 1955, and in separate pamphlet form.)

12. Messrs. Leo V. Bodine and Richard G. Kimbell of the National Lumber Manufacturers Association appeared before the Board to comment on certain features of NFPA Standard No. 101C on Interior Finish as adopted by the Association at the 1955 annual meeting on recommendation of the Committee on

Safety to Life. They indicated that the establishment of the figure 175 as the upper limit of combustibility on Class C materials constituted an unnecessary hardship to the lumber industry and discriminated against one species of wood. They requested that the Board refer this matter back to the Committee on Safety to Life for further consideration and meanwhile suspend distribution of the standard. After discussion, it was voted to refer the matter to the Committee on Safety to Life for further consideration and authorize the committee to submit their recommendations on this matter to the Board at the January Board meeting. No action, however, was taken on the request for suspension of distribution of the standard in view of the fact that the standard as presently being circulated represents the official action of the Association taken in accordance with regular NFPA procedure.

Technical Advisory Committee

13. The report of the Technical Advisory Committee as presented by Chairman A. L. Brown was accepted including action on the following:

(a) An official scope statement for the Committee on Building Materials created at the last Board meeting was adopted to read as follows:

"Advisory to other NFPA committees, and to the Association. Provides information on specifications for building materials, consults with other committees, on request reviews standards prepared by other committees, makes recommendations to provide for impartial treatment of all building materials with provisions appropriate to their individual suitability for various uses, and deals with policy matters in which all building material producers have a common interest."

(b) A new Committee on Industrial Fire Apparatus was created in accordance with the recommendation of the NFPA Industrial Committee, this committee to prepare standards for fire apparatus for industrial situations where the standards for municipal fire apparatus are not applicable and where a degree of production is needed beyond that afforded by equipment such as that already covered by the NFPA Standards on First Aid Extinguishers, Standpipe and Hose Systems, and Outside Protection. The Technical Advisory Committee was authorized to proceed with the selection of the personnel and development of a scope statement, subject to confirmation by the Board at its next meeting.

(c) A new Committee on Internal Combustion Engines was created and jurisdiction over the existing standard on this subject, NFPA No. 37, was transferred from the Committee on Gases to the new committee. The Technical Advisory Committee was authorized to proceed with the organization of this committee to include appropriate representation of both gas and liquid fuels, manufacturers of internal combustion engines, and general fire protection interests.

(d) The committee reported continuing consideration of the matters of policy involved in instructions to NFPA representatives on committees of other organizations as to their responsibilities and authority on voting on behalf of the NFPA and indicated the intention to make a more specific report on this subject at the next meeting of the Board. Progress was also reported on various other matters in the field of the Technical Advisory Committee.

14. It was voted to confirm the list of committee appointments submitted with the Board agenda, also a supplementary list submitted at the meeting. It was further voted to reappoint for the coming year all members of all NFPA technical committees, except those replaced, retired, or dropped by reason of inactivity. The Technical Advisory Committee was authorized to proceed to other pending committee appointments, subject to confirmation by the Board at its next meeting.

15. The Technical Advisory Committee for 1955-1956 was appointed as follows: A. L. Brown, Chairman, Hylton R. Brown, T. Seddon Duke, John A. Neale, Henry G. Thomas.

American Standards Association

16. The relations of the NFPA with the American Standards Association were discussed and the entire subject referred to the Technical Advisory Committee for consideration and report back to the Board at its next meeting. A communication from the American Standards Association concerning alleged lack of balance of the Committee on Dust Explosion Hazards was presented during the course of the discussion but no action was taken thereon pending the report of the Technical Advisory Committee on this general subject.

17. Discussion of the general policies involved in the adoption of NFPA standards by reference was deferred to the next meeting of the Board.

Substandard Devices

18. Messrs. Bugbee and Tryon reported on a number of cases of rackets in fire detection and extinguishment where the NFPA name has been improperly used in sales promotion efforts for products and services of dubious merit, also cases where various promotions of fire detection and extinguishing equipment seemed contrary to the public interest, although no element of fraudulent intent was involved and where, in fact, ill-informed promoters may believe that they are acting in the interest of public safety. The discussion reviewed the problems confronting the NFPA staff in dealing with such matters, the need for vigorous action to avoid improper use of the NFPA name including, for example, the dropping of NFPA members who use the Association's name improperly, and continuing educational efforts to provide the public with information helpful in distinguishing between standard and substandard fire protection products. Mr. Bugbee indicated that such NFPA activities in the public interest might conceivably result in legal attack against the Association on the part of some aggrieved promoters but expressed the belief that the Association as a whole and the NFPA staff particularly had a duty to the public which should be fulfilled. This report was approved.

Advertising Policy

19. Mr. Morgan reported a protest from an NFPA member concerning the assignment of the back cover advertising space in the NFPA QUARTERLY to a single advertiser and the request that the Board act to rotate such preferred space among different advertisers. After discussion, it was voted to continue the present policy, which represents the prevailing practice in the advertising field, of continuing to allocate the space to the original advertiser so long as he desires it and is willing to pay the specified premium price therefor.

Other Reports

20. Chief Engineer Bond reported on various developments in civil defense and other matters in Washington.

Report on European Trip

21. General Manager Bugbee and Assistant Technical Secretary Tryon reported on their recent trip to England, France, Belgium, Denmark and Sweden, during which contacts were made with NFPA members and various fire protection organizations. This report indicated that the NFPA is held in very high regard in all the countries visited and that as a result of the visit we may expect to enjoy increasingly close cooperation with our members and other fire protection authorities in the countries covered to the mutual benefit of the Association and of the general cause of fire safety.

22. It was voted to hold the next meeting of the Board at the Union League Club in New York on Thursday, January 26, 1956.

Fire Protection For Chemicals – Part 5*

By Charles W. Bahme

EDITOR'S NOTE: The following article is the fifth installment of a manuscript prepared by Mr. Bahme for class instruction in fire protection engineering and for the training of members of the fire service charged with responsibility of safeguarding life and property against the fire and explosion hazards of dangerous chemicals. It should also be valuable reference material for the industries concerned with the manufacture, storage and transportation of chemicals, fire prevention authorities and others concerned with life and property safety.

Rather than delay publication until the manuscript could be published as a unit, the NFPA is making the information available by serial publication in the *Quarterly*. Readers are invited to submit their comments to the NFPA Executive Office.

The recommendations in this article are those of the author and do not necessarily reflect the official recommendations of the National Fire Protection Association, the U. S. Navy or the Los Angeles Fire Department.

Data on General Classes of Chemicals (Continued)

HALOGENS

The halogens are the four chemical elements: fluorine (F), chlorine (Cl), bromine (Br), and iodine (I). They form the halogen acids: hydrofluoric (HF), hydrochloric (HCl), hydrobromic (HBr), and hydriodic (HI) acid. The introduction of a halogen into an organic compound, either by addition or substitution is called "halogenation," e.g. chlorination, bromination. With metals, the halogens form compounds called "halides," e.g. sodium chloride (NaCl), sodium fluoride (NaF). (See **Fluorides.**)†

Halogens—Fluorine

Fluorine is a greenish-yellow gas, 1.3 times heavier than air, somewhat like chlorine, but more reactive. In fact, it is one of the most reactive elements known. It is intensely poisonous and irritating, and reacts with hydrogen and many organic materials with explosive violence. It is explosive in contact with metallic powders, and attacks glass and most metals.

It also reacts explosively in contact with water vapor to form hydrofluoric acid and oxygen.

Charles W. Bahme, a personal member of the NFPA Committee on Chemicals and Explosives, has had more than 17 years of varied experience in the Los Angeles Fire Department, having been a fire fighter, fire inspector, arson investigator and head of its Public Relations Bureau. He is presently a Battalion Chief in the fire fighting force of the Los Angeles Fire Department. He is an attorney, having membership in the California State Bar Association.

*Part 1 was published in the April 1952 *Quarterly*, pp. 323-346; Part 2 was published in the April 1953 *Quarterly*, pp. 332-353; Part 3 was published in the July 1953, *Quarterly*, pp. 86-97; Part 4 was published in the April 1955, *Quarterly*, pp. 403-407.

†See "Fire Protection for Chemicals" — Part 2, published in the April 1953 *Quarterly*.

Fluorine combines with virtually every material under suitable conditions, and with most materials combination takes place spontaneously at room temperature.

It is shipped in nickel, monel or steel cylinders, and is classed by the ICC as a flammable gas.

As fluorine causes severe flesh burns and is a serious inhalation hazard, areas where it is suspected that fluorine is leaking should not be entered without self-contained breathing apparatus.

Fluorine cylinders should be stored in isolated concrete rooms, adequately ventilated and locked.

One article which sets forth elaborate fluorine handling precautions[38] calls for two trained people to be present at all times, an alarm system, remote controls, and ¼-inch steel barricades or bricks.

Fluorine piping must be free of contaminants such as moisture, grease and pipe dope which may cause hot spots in the piping. If the metal reaches its ignition temperature it melts and bursts, producing a metal-fluorine flame and explosive pressure which will eject the molten metal several feet.

In one series of tests cylinders of fluorine withstood a temperature of 212°F. for 10 days without explosion. When subjected to impact, no explosion occurred. When pierced with 30 caliber bullets, the steel cylinders ignited at the opening, but the nickel ones did not.

Fluorine Disposal

Disposal of small laboratory amounts of fluorine can be accomplished by passing it over sodium chloride. Chlorine is formed, which can then be absorbed by soda lime, lime slurry, etc. A solution of 5 to 10 per cent by weight of caustic soda destroys fluorine gas, provided the contact time exceeds one minute. This method is recommended for industrial use.

If a cylinder leak occurs, water should not be discharged on the leaking container. Persons exposed to the gas should be evacuated, and exposures from any fire should be protected by fire fighters wearing self-contained breathing apparatus.

Halogens—Chlorine

Chlorine is a greenish-yellow gas, with a vapor density of 2.49 and boiling point of –30.1° F. In a cylinder, chlorine is under 82 psi at 68° F., and 140 psi at 100° F. and is mostly in liquid form. The liquid has a specific gravity of 1.47. Chlorine is only slightly soluble in water. Chlorine is highly toxic and irritating, having a toxic threshold rating of 1 ppm (the same as phosgene)[39]. A few deep breaths of concentrations of 1000 ppm are likely to be fatal. A concentration of 40 to 60 ppm is dangerous for even a short exposure.

The Chlorine Institute, Inc.[40] states that chlorine produces no cumulative effects and complete recovery occurs from mild exposure.

The ICC requires a green label on chlorine vessels, indicating a nonflammable compressed gas (the same label required for compressed air).

Chlorine cylinders have a fusible plug on the valve just below the valve seat which is designed to melt at between 158 and 165° F. Even though equipped with fusible plugs, the sudden application of intense heat may cause chlorine cylinders to explode, a statement that can be made about most cylinders of compressed gases.

The ton container is a steel tank about 80 inches long and 30 inches in diameter (dished on both ends), having three fusible plugs in each end. Tank cars have a safety valve located at the center of the dome. On ICC 105A300 tanks, the valve is set to be vapor tight at 180 psi, and on ICC 105A500 tanks, valves are set to be vapor tight at 300 psi.

Chlorine—Fire Hazard

Chlorine is nonflammable, but, like oxygen, is capable of supporting the combustion of certain substances, and of forming highly dangerous compounds with several elements. Most hydrocarbons react readily with chlorine, in some cases with the evolution of heat and light,[41] and if mixed with hydrogen, methane, ethylene, ether, or with acetylene, chlorine will explode in sunlight or in artificial light. Mixtures of chlorine and hydrogen composed of more than 5 per cent of either component are very explosive.[41] Also, it is reported that paper and textiles which have been soaked in turpentine, resin, or ethereal oils, will ignite spontaneously when placed in a chlorine atmosphere. In a chemical plant where chlorine cylinders and drums of benzene were stored in the same room a violent explosion occurred that killed and injured several persons and wrecked the building. Investigators concluded that the explosion took place when chlorine leaking from a cylinder came in contact with benzene vapors.

Sodium, potassium, phosphorus and certain other metals will burn in an atmosphere of chlorine gas. Sodium carbide and certain finely divided metals are spontaneously flammable in contact with chlorine.

Chlorine forms chlorates (some of which are explosive) when combined with oxygen, and the sensitive explosive, nitrogen trichloride, when passed through ammonia (either anhydrous or aqueous).[42] Until recently, nitrogen trichloride was extensively used for bleaching flour in the United States. Millers now use chlorine dioxide. Although chlorine dioxide is unstable and capable of exploding when mishandled under excessive temperatures and concentrations, as prepared and utilized in flour mills, fat rendering plants, water sterilization plants, etc., the hazards of its production and use by approved methods can be adequately safeguarded.[42]

At ordinary temperatures, dry chlorine does not appreciably corrode steel or most other metals. At elevated temperatures it may attack metals rapidly. In the presence of moisture, chlorine is very corrosive.

When involved in a fire at a temperature of 300° F., chlorine will react with steel cylinders, burning a hole through them. Tests conducted at the Factory Mutual Laboratory showed that the escaping gas will extend as far as 500 feet. In one instance chlorine escaping from a tank car traveled over 2000 feet.

Chlorine Storage

Chlorine should never be allowed in the basements of public or semi-public buildings (e.g., where swimming pools are located) unless under specially designed safety conditions. Chlorine, if stored inside, should be in a fire-resistive storage room, designed for toxic gases.

Chlorine Leaks

One ton of chlorine will form almost 10,000 cu. ft. of gas. Quoting from the

Chlorine Manual,[40] "It is obvious that a liquid chlorine leak may be extremely hazardous as the quantity of chlorine discharged from a liquid leak will be many times that discharged from a gaseous leak of the same size." The Manual gives the following advice:

1. Chlorine leaks always get worse if they are not corrected promptly.

2. Keep to the windward side of the leak and higher than the leak.

3. Authorized, trained personnel equipped with gas masks should investigate. All other persons should leave the area, preferably to windward, or in a direction to the flank. If the leak is extensive, all persons in the path of the fumes should be warned to leave.

4. If the leak occurs in equipment in which chlorine is being used, the container valve should be closed immediately.

5. If the container is in such a position that chlorine is escaping as a liquid, the container should be turned so that chlorine gas escapes. (The quantity of escaping gas from a leak is about one-fifteenth the amount that escapes as a liquid through the same hole.

6. Water should not be sprayed on a chlorine leak. The resulting corrosion will make the leak worse and the heat supplied even by cold water will cause the liquid to change to gas at a faster rate.

7. If a chlorine leak occurs in transit in a congested area, the operator should put on a mask and keep the vehicle moving until it reaches open country. If the leaking containers are on a wrecked vehicle, they should be turned so that only gas escapes. If possible they should be hauled away to an uncongested area.

8. Pinhole leaks in cylinders and ton containers can sometimes be temporarily stopped by driving a tapered wooden plug or metal drift pin in the hole. Extreme care should be exercised in driving in the plug as the wall area surrounding the hole may be thin, and crumble, thereby making the leak worse. (Before this procedure is attempted the container should be turned so that only gas is escaping.) As soon as possible, the cylinder must then be emptied of its contents.

According to the Chlorine Institute, Inc., a leaking cylinder should not be submerged in water unless there is no other recourse. Where it is necessary to submerge a cylinder, it should be weighted so that it does not come to the surface again as it empties.

The Chlorine Institute, Inc.[40] states that at regular points of storage and use of chlorine, emergency preparation should be made for disposing of contents of cylinders and ton containers.

Chlorine may be absorbed in caustic soda, soda ash or hydrated lime solutions. Caustic soda is recommended as it absorbs chlorine most readily. (For a ton container, 2,500 lbs. of caustic soda and 800 gals. of water would be required). The chlorine is passed into the solution through an iron pipe or rubber hose weighted to keep it under the surface.

All chlorine cylinders and containers (whether portable or fixed) should have a tag bearing the emergency telephone number of the supplier's agent who can be called to the scene to lend assistance in case of leaks. The fire department should also have the number.

One instance of a chlorine leak may be of interest. While a tank car of chlorine was being heated by steam coils to

speed up unloading, excessive heat caused the safety valve to open and release chlorine to the air. Hose streams unwisely directed at the valve probably caused it to corrode and stick in the open position. Escaping gas caused about a hundred thousand dollars etching and corrosion damage to machinery in buildings located within a half mile of the tank car.

The National Fire Protection Association[43] states that it is dangerous to neutralize chlorine in a room with ammonia, and recommends that the two gases not be stored in the same room. This policy is corroborated by an explosion on a naval station where the exhaust pipe on an engine which operated the well pump set the roof on fire. Beyond a frame partition, an ammonia cylinder and a chlorine cylinder were in the same room. Apparently the heat which developed forced ammonia out around the valve stem (there were no soft plugs), and the fusible plug on the chlorine cylinder let go. While the responding fire apparatus was still a hundred yards away, an explosion occurred which tore the building apart.

Chlorine Cylinders in Fires

Unless heat envelops a cylinder so rapidly that the fusible plug cannot relieve the pressure the cylinder will not explode. Firemen who are working in an area where chlorine gas is present should be equipped with breathing apparatus. A fire which opened the fusible plugs of chlorine cylinders in Los Angeles caused sixteen fire fighters to become ill.

Halogens—Bromine

Bromine (Br) is a dark, reddish-brown, corrosive liquid, with a specific gravity of 3.18, boiling point 138° F., and vapor density 5.5. It is slightly soluble in water. Bromine causes fires in contact with combustible materials, such as wood, excelsior and sawdust.

Bromine is used as a general oxidizing agent, and in dyes, inks, metal refining, disinfectants and military poison gas.

Bromine—Storage and Handling

Bromine is shipped in 6½-pound bottles and in lead-lined steel drums holding 200 pounds. It is also transported in one- to five-pound glass ampoules.

Bromine should be stored in a cool place with plenty of ventilation. Cases should be stacked to allow air circulation. Bromine drums must never be rolled. Excessive pressure can build up if drums are stored in the sun or in a poorly ventilated building, or in box cars during hot weather.

Bottles must never be carried from place to place by hand, but in a container with a handle, and the bottle must be surrounded by expanded vermiculite or similar noncombustible absorbent packing.

The stoppers of bromine bottles are set in cement or plaster of Paris, and frequently cannot be removed without breaking the bottle. The application of flame or hot water may develop enough pressure to burst the bottle, although hot water may be run on the seal if the lower part of the bottle is kept cool with cold water. Glass ampoule-type containers are easily opened by breaking off the end. The liquid bromine is then poured into a bottle and stored in a refrigerator or under a hood when not in use.

Bromine—Health Hazard

Bromine fumes are extremely irritating as well as toxic, having a threshold limit value of 1 ppm.[39] Bromine liquid is caus-

tic to the skin, inflicting deep, painful burns. Following inhalation of bromine fumes, there may be a delay of several hours before development of serious symptoms. (Inability to cough denotes severe exposure.)

In first aid treatment, the degree of gassing suffered determines the type of treatment. In addition to the customary treatment for respiratory difficulties, it is important to rinse the mouth with a 10 per cent solution of sodium thiosulfate (sometimes called "Hypo" by photographers).

Decontaminants which may be used include milk of lime slurry, saturated sodium thiosulfate solutions, and spirits of ammonia.

Bromine—Fire Fighting

Bromine may cause fires when in contact with combustible materials. One large chemical supplier reported that where lead caps for bromine bottles had contained impurities, the caps were dissolved by the bromine, releasing the fumes and causing ignition of the wooden cases above them.

In the event of spills, the bromine can be soaked up in a neutralizing absorbent agent, using one of the above mentioned decontaminants. Self-contained breathing apparatus should be worn while performing the work. Although bromine is not very soluble, spills can also be washed away with water to a safe drainage location. Where the fuming bromine is in an open container, water can be floated on top.

In cases of fires involving broken bromine bottles, water in spray form is desirable to reduce the dangers of splashing.

Halogens—Iodine

Iodine is usually in the form of purplish-black, volatile crystals, which are poisonous and corrosive. It is insoluble in water, has a specific gravity of 4.98, and a melting point of 239° F. It is usually derived from the ashes of seaweeds or by precipitation from sodium nitrate liquor, by addition of sodium bisulfite solution.

It is shipped in ¼-pound to 50-pound bottles, and in 100- or 200-pound kegs.

It is used as a germicide, in dyes, and pharmaceuticals.

Von Schwartz[14] states that iodine will explode spontaneously when diffused with ammonia, and that it is explosive with turpentine or lead triethyl.

HYDRIDES

Most hydrides are compounds of hydrogen and metals. Metal hydrides react with water to form hydrogen gas.

Some hydrides, such as sodium hydride and potassium hydride are spontaneously flammable in air. Metal hydrides should be stored in hermetically sealed containers in a cool, dry place. Fires involving hydrides can be smothered with an inert smothering material such as dry, finely divided calcium magnesium carbonate (dolomite). Do not use water or other conventional types of fire extinguishing agents on hydride fires.

HYDROCARBONS

A hydrocarbon is any compound composed of carbon and hydrogen. It has been estimated that there are over one million hydrocarbons. Hydrocarbons may be *saturated* (where all bonds or linkages between adjoining carbon atoms are satis-

fied), as in the paraffin or methane series, or *unsaturated,* in which all bonds of adjoining carbon atoms are not satisfied, as in the olefin series. The lowest members of the paraffin series are methane (CH_4), ethane (CH_3-CH_3), and propane (CH_3-CH_2-CH_3). The lowest member of the olefin series is ethylene ($CH_2=CH_2$), a gas commonly used in anesthesia and for ripening of fruits. Its use in surgery is discussed under **Anesthetics.*** Regulations controlling its use for fruit ripening have been published by the National Board of Fire Underwriters[44] and by the Los Angeles Fire Department.[22]

Another grouping of hydrocarbons is based on molecular arrangement. The *aliphatic* hydrocarbons are compounds in which the principal molecules are arranged in chains, e.g., ethylene, propane, hexane, while the *aromatic* hydrocarbons have their carbon atoms arranged in rings (cyclic), e.g., benzene, toluene and xylene.

Hydrocarbons — Fire Hazard

Like all organic compounds, the hydrocarbons vary in degree of flammability, ranging from highly flammable gases, such as methane and ethane, to combustible solids or semi-solids, such as asphalt and fats. Details of fire prevention and fire protection for hydrocarbon are available in several publications.[43,45,46]

A publication of Underwriters' Laboratories, Inc.[47] discusses the various factors which must be considered in dealing with any liquid, whether a hydrocarbon or not. It explains the meaning and relationship of volatility, ignition temperature, flammable limits, combustion intensity, hazards by combination, vapor density, nature of products of combustion, toxicity, and chemical stability.

Hydrocarbons — Toxicity

The toxic effects of hydrocarbons vary considerably. For example, ethylene oxide, sometimes used as a fumigant, is classed as an irritant which chiefly affects the upper respiratory tract,* while ethane and methane are asphyxiants. Other hydrocarbons have an anesthetic effect, such as (in decreasing order), the acetylene hydrocarbons, the olefins (ethylene to heptylene), and paraffin hydrocarbons (propane to decane). The aromatic hydrocarbons — benzene, toluene and xylene — are systemic poisons. The Manufacturing Chemists' Association states[1] that acute poisoning may result from inhaling a high concentration of benzene vapors in a few minutes, causing a rapid tightening of the leg muscles, dizziness, shortness of breath, and possible hysteria. This warning should be closely heeded, for the records indicate that many firemen have been seriously affected by benzene vapors during the course of fighting fires where benzene spills have been involved.

For a discussion of the toxic hazards of trichlorethylene, tetrachloroethane, chloroform, and freon, see **Chlorinated Hydrocarbons.***

HYDROSULFIDES

The hydrosulfides are the same as sulfhydrates, and include the sulfhydryls, thioalcohols, thiols, sulfur alcohols, or mercaptans. They are sometimes erroneously referred to as sulfides.

*See first installment of "Fire Protection for Chemicals," published in the April 1952 NFPA QUARTERLY.

*See **Fumigants** in "Fire Protection for Chemicals" — Part 2, for a more complete discussion of ethylene oxide.

These compounds contain the SH group, and are analogous to hydroxides in which the oxygen is replaced by sulfur.

Although sodium hydrosulfide ($NaSH \cdot 2H_2O$) can be in the form of colorless needles which are soluble in water, many of the liquid mercaptans are insoluble.

The mercaptans (thioalcohols) are used for odorizing natural gas because of their very sharp, unpleasant odor.

Hydrosulfides — Fire Hazard

The hydrosulfides are flammable liquids. For example, ethyl mercaptan (or ethyl sulfhydrate) has a flash point of −40°F., specific gravity of 0.83, a vapor density of 2.1, and boiling point 98°F.

HYDROSULFITES

Hydrosulfites are salts containing the S_2O_4 group.

Sodium hydrosulfite ($Na_2S_2O_4$), for example, is a yellowish or grayish white powder, and is used as a bleaching agent and for removing dyes from fabrics. It is very soluble in water.

It is classed by the ICC as a flammable solid, and requires the yellow label. It oxidizes in air and even more readily in the presence of moisture, giving off irritating sulfur dioxide gas. Sodium hydrosulfite is combustible and is liable to ignite if allowed to become damp. It should be stored in a cool, dry place away from other materials.

HYDROXIDES

Inorganic compounds containing the hydroxyl group (OH) are called hydroxides, whereas organic compounds containing the hydroxyl group are called alcohols. See **Alcohols.***

The common hydroxides are sodium hydroxide, potassium hydroxide and ammonium hydroxide. These and most other hydroxides are soluble in water. They are not combustible but react with water to generate heat. Hydroxide solutions may generate hydrogen on contact with zinc, galvanized metals or aluminum. For a discussion of sodium hydroxide and potassium hydroxide, see **Alkalis (Caustics).***

HYPOCHLORITES

Hypochlorites are compounds containing the group ClO, the most common of which are the hypochlorites of calcium ($Ca[ClO]_2 \cdot H_2O$), sodium ($NaClO \cdot 2\frac{1}{2}H_2O$) and potassium (KClO).

Sodium hypochlorite hydrate consists of greenish-yellow crystals, and is liable to explode when warmed or placed in contact with organic matter. Its use as a germicide and bleaching agent, together with its dangerous reactions, are reported in Kingzett's Chemical Encyclopedia.[48]

Calcium hypochlorite, which is the same as calcium oxychloride, is probably the most common chemical referred to as "bleaching powder." When it contains more than 8.8 per cent available oxygen it is classed by the ICC as an oxidizing material and requires a yellow label.

Calcium Hypochlorite Hazards

Calcium hypochlorite is not of itself combustible, but at high temperatures liberates oxygen to support combustion. Therefore it should be stored in a cool, dry place, away from combustible materials and acids. Since chlorine is freely released when exposed to the air or mois-

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ture, it should not be stored near containers of turpentine or other hydrocarbons whose vapors will spontaneously explode when diffused with chlorine.

If mixed with organic materials or flammable liquids, friction against the packing may lead to heating and spontaneous ignition of the mixture.

In fighting a fire where this material is involved ventilation is important and respiratory protective devices should be worn if the pungent odor of chlorine is noticeable. Water spray is recommended as the preferred extinguishing agent, and can be used for cooling exposed drums of the chemical. If a container of calcium hypochlorite is exposed to excessive heat or the direct rays of the sun, gases liberated may develop sufficient pressure to rupture the container.

Chlorine, a poison gas, is liberated from this material when subjected to heat or moisture. (See **Halogens**, for a discussion of chlorine hazards.)

HYPONITRITES

These are compounds containing the NO or the N_2O_2 groups. It is reported that potassium hyponitrite ($K_2N_2O_2$) detonates upon warming.[14]

HYPOPHOSPHITES

These are compounds containing the PO_2 or the H_2PO_2 groups.

The hypophosphites of sodium, potassium, and calcium are white crystals which melt but decompose when heated to form phosphine, a spontaneously flammable and poisonous gas, and other products.

Hypophosphites burn at elevated temperatures, and form powerful explosives when mixed with nitrates, chlorates and other oxidizers.

Hypophosphites are soluble in water, and are shipped in single trip 25 and 50 lb. steel barrels on which the ICC does not require a label. They are used in medicines, in preparations of salts and in organic synthesis.[49]

HYPOSULFITES

Hyposulfites are sometimes referred to synonymously with hydrosulfites. The most common representative of the group is sodium hyposulfite ($Na_2S_2O_3 \cdot 5H_2O$) (sodium thiosulfate), often referred to as "hypo." Sodium hyposulfite consists of white crystals, and is used as a fixing agent in photographic work. No fire or health hazard was noted in the literature.

IODATES

Iodates are the salts of iodic acid and contain the group IO_3. Potassium iodate (KIO_3) consists of colorless deliquescent crystals that are soluble in water.

The iodates are oxidizing agents. For a description of typical hazards and precautions, see **Oxidizing Agents.***

IODIDES

When iodine combines with a metal it forms a compound such as potassium iodide (KI) or sodium iodide (NaI), the crystals of which are sometimes used in medicine and photography. See **Halogens** for a discussion of the hazards of iodine compounds. See **Phosphides*** for data on the explosive phosphonium iodide.

LACTATES

These are salts of lactic acid ($C_3H_6O_3$) which are derived by fermentation of

*To be included in a future installment of "Fire Protection for Chemicals."

milk, sugar, starch, etc. Sodium lactate ($CH_3CHOHCOONa$) is a pale syrupy liquid which readily absorbs moisture. Lactates will burn under certain conditions but are not considered hazardous.

LIQUEFIED PETROLEUM GASES

Liquefied petroleum gases (LP Gases) are commonly referred to as propane or butane, one of which is usually the principal component. Smaller amounts of propylene, butylene, isobutane, ethane, ethylene and isopentane may be present.

LP Gases have a high heat value per cubic foot (see Table 13) and are used for practically every gas fuel requirement.

Table 13. Average Properties of Commercial Propane and Butane

	Propane	Butane
Specific gravity of liquid at 60°F (Water=1)	0.509	0.582
Volume of gas per lb at 60°F and atmos. pres.	8.5 cu ft	6.5 cu ft
Boiling point, at 14.7 lbs/sq in abs.	−51°F	15°F
Vapor pres. at 100°F, approx.	192 psig	59 psig
Specific gravity of gas (air =1) 60°F, 30" Hg	1.55	2.07
Heat of combustion of gas per cu ft at atmos. pres. and 60° F, approx.	2557 Btu	3371 Btu
Amount of city gas of 550 Btu per cu ft equivalent in heat value to gas from one gallon of liquid	168 cu ft	193 cu ft
Explosive range by volume with air	2.2-9.5%	1.9-8.5%
Heat of vaporization per lb	185 Btu	167 Btu
Wt per gal of liquid at 60°F	4.24 lbs	4.84 lbs

Liquefied Petroleum Gas Hazards

In the gaseous state, LP Gases present fire and explosion hazards similar to natural or manufactured gas. In the liquid state, the fire hazards are similar to those of a highly volatile flammable liquid.

As indicated in Table 13, liquefied petroleum gases are heavier than air. Special attention must therefore be given to ventilation. LP Gases are practically odorless requiring the addition of an odorizing agent so that leaks can be readily detected by smell.

According to information published by a large LP Gas producer[64] liquefied petroleum gases are non-poisonous but are slightly anesthetic when high concentrations are inhaled over a considerable length of time. Liquid LP Gas, due to its low boiling point, will cause a "freezing burn" or frostbite and therefore care should be taken to prevent contact of liquid LP Gas with the skin.

LP Gas — Storage and Handling

LP Gases are stored in pressure containers constructed to hold the pressure of the particular product stored at 100°F with a suitable factor of safety. NFPA Standards[62] specify the design working pressure for various classes of containers.

Bulk storage is usually in aboveground steel tanks. ICC cylinders of various sizes are used for small quantity storage.

ICC cylinders are provided with safety relief devices designed to prevent rupture of the container, if subjected to fire. Safety devices for other than ICC containers are published in NFPA No. 58.[62]

LP Gas — Utilization

The generally accepted criteria for the safe design, construction, location and operation of liquefied petroleum gas installations are the standards on the subject developed by the National Fire Protection Association.[61,62,63]

LP Gas — Fire Fighting

An excellently prepared pamphlet on liquefied petroleum gases[64] contains the

following recommendations for fighting LP Gas fires.

"Suppose that there is fire under way where liquefied petroleum gas equipment is installed and the equipment is exposed to excessive heat. What is the procedure to follow? It should be remembered first of all that pressure in an LP-Gas container is commensurate with the temperature of the contained product. Therefore, it is logical and desirable to keep the container as cool as possible in order to prevent or minimize any discharge of gas through the relief valve due to excessive pressure build-up. This can be done by applying a stream of water to the container. If it is possible and practicable, it is wise to disconnect the containers (small containers and cylinders), remove them from the fire zone and place them at a safe distance in an upright position. It is important to keep containers always in an upright position in order to prevent the discharge of liquid through the relief valve.

"It should be remembered that when fighting LP-Gas fires it is generally advisable to permit any escaping gas to burn itself out. The fire can be controlled within limits. However, if the fire is extinguished without stopping the leakage, the gas may accumulate and under certain conditions, if reignited, explode.

"Should the upper portion of the container including the container valves be in a protecting device or hood which is locked, the lock can be broken by a hammer or axe and the container valve then shut off with the hand wheel or with an adjustable wrench. If the container is to be removed after the valve is closed, the flexible connections can be disconnected or, if necessary, cut with an axe.

"If the container relief valve has opened and the gas is discharging through the relief valve and is burning, play a stream of water on the container to cool the liquid and reduce the pressure therein. This will cause the relief valve to close. If the container is equipped with a fusible plug which has opened, it is safest to let the escaping gas continue to burn until the contents are exhausted, for the escaping gas, if not burned, might create an added hazard.

"If a fire is adjacent to a liquefied petroleum gas container, but no LP-Gas is escaping, efforts should be made to keep the container cool, thus diminishing the possibility of a build-up in pressure great enough to open the safety relief device. If a fire occurs at a large installation such as a bulk plant or an industrial installation, efforts should be directed toward cooling the storage tank by the application of streams of water. If possible, any fire around the container which is heating the contents of the tank should be extinguished. When the source of heat is removed, the pressure within the container will diminish and the relief valve will close. If gas is escaping at the safety relief valve stacks, it should be ignited if doing so creates no further hazard. Such a torch will be safe as it will diminish and go out when the tank pressure is reduced below the set pressure of the relief valve.

"If a gas line is broken and the escaping gas ignited, one of the first considerations should be to stop the flow of gas. Generally, this can be done by closing the valves at the storage container if no other means are provided. After the flow of gas is stopped, an extinguisher such as dry powder chemical or carbon dioxide should be used to extinguish the fire. It is

important to remember that the fire should be controlled and not extinguished, unless the gas leakage can be stopped.

"These same principles should be followed in event of a fire involving an LP Gas tank truck or tank car."

MALONATES

The malonates are salts of malonic acid. They will burn under certain conditions but are not considered hazardous.

MANGANATES

The manganates are oxidizing agents containing the group MnO_4. For a discussion of typical hazards and precautions, see **Oxidizing Agents.*** See also **Permanganates.***

MERCAPTANS

See **Hydrosulfides.**

METALS

For a discussion of lithium, sodium, potassium, rubidium and cesium, see **Alkali Metals.**†

The hazards of metals vary with the individual metal, the form or state of division, purity and other factors.

Almost any metal dust (exceptions: the noble metals, copper, nickel, some impure irons, certain lead powders and probably some others) will explode when dispersed as a cloud in the air, if a suitable source of ignition is present. The relative flammability and explosive pressures developed by powdered metals depend mainly on the nature of the metal, its purity and the fineness and shape of the particles. The smaller the size, the greater the flammability.

Flammability of Metal Powders

Metal powders have been grouped according to their flammability.[50] Zirconium, magnesium and its alloys, aluminum, and titanium powders are the most hazardous. Reduced and carbonyl iron, manganese, zinc and silicon powders are in an intermediate group. Cadmium, copper, chromium, lead and milled iron powders have a low order of flammability and explosibility, although it cannot be said that the latter are nonexplosive.

Relative flammability is not in the same order as relative ignition temperature. Minimum ignition temperature for a powder of a given metal will vary depending on size of the particle, the time of contact between the dust cloud and the source of ignition, the density of the cloud and the presence of impurities. The source of ignition must not only be of sufficient temperature but also of sufficient duration and energy content. Zirconium, uranium and uranium hydride powders will, under some conditions, ignite spontaneously when dispersed in air at room temperature (possibly static spark ignition), whereas other powders show a range of ignition temperatures from 500°F. for reduced iron, to 1650°F. for chromium and milled iron.

The minimum electrical-spark energy required for ignition of a number of powders is very small. In these cases, if the ignition temperature is reached, the quantity of heat is sufficient.

In the relative flammability tests conducted by the Bureau of Mines,[50] it was determined how much inert dust, such as fuller's earth, must be admixed to prevent combustion. It was found that in rare instances certain metal powders have a lower ignition temperature when mixed

*To be included in a future installment of "Fire Protection for Chemicals."

†Published in the first installment of "Fire Protection for Chemicals."

with inert dust than when pure. One sample of magnesium powder ignited at 1365°F. when pure, and when mixed with 50 per cent fuller's earth, ignited at 1292°F., for the inert dust promoted dispersion. Mixtures of magnesium and inert materials up to 90 per cent (higher percentages were not tried) did not prevent its burning when dispersed in the air.

Explosive Concentration

The minimum concentration of 200-mesh powder to permit ignition from a high voltage, low energy spark ranged from 0.02 ounce to about one-half ounce per cubic foot, depending upon the metal.

Metal Dust Explosion Pressures

With respect to pressures developed in metal dust explosions, the highest pressure was obtained from a stamped aluminum dust cloud, when a value of 89 psi was recorded.[51] The maximum rate of pressure rise in this test was nearly 5700 psi per second. Fortunately most dust explosions do not occur under optimum conditions since it is doubtful that any type of pressure relieving arrangement could prevent damage from such pressures. For a discussion of explosion venting, see the "Guide for Explosion Venting."[52]

Effect of Inert Gases

Tests conducted on the effectiveness of inert gases to prevent metal dust explosions showed that, in general, nitrogen is a better diluent than carbon dioxide, and helium is better than nitrogen.[65] The use of carbon dioxide to replace air as the surrounding atmosphere in the production of powders of magnesium, magnesium alloys, titanium, and zirconium will not prevent ignition by small electric sparks. For practical purposes, aluminum could be added to this list, for the oxygen content must be below 3 per cent to eliminate the hazard. Even when in a quiescent state, zirconium and magnesium and its alloys burned vigorously in both carbon dioxide and nitrogen, and the combustion started at a lower temperature in nitrogen than in carbon dioxide. Reduced iron burned in air at 555°F., in nitrogen at 390°F., but was inert in carbon dioxide at 1650°F.

Liberation of Hydrogen by Metals

Metal powders not only present a dust explosion hazard, and in some cases a fire hazard (owing to ready ignition and intense combustibility), but also in some instances, e.g., magnesium and aluminum, heat spontaneously and liberate hydrogen when moist. Fires have been reported which were started when the hydrogen that was liberated from moist metal in a closed drum built up sufficient pressure to rupture the drum.

Explosive Properties of Metals

In addition to the hazards of dust explosion, ready ignition, and generation of hydrogen when wet, mixtures of magnesium or aluminum powder with water or alcohol are reported as potentially more powerful explosives than the usual military materials. According to this reference,[53] water with magnesium was the most sensitive to shock, while water with aluminum, and methyl alcohol-magnesium mixtures were less sensitive and required a booster detonator.

Metals — Aluminum

Aluminum has a sufficiently high ignition temperature so that its burning is not ordinarily a factor in fires except that fine chips and shavings behave somewhat the

same as magnesium chips. Guidance on prevention of fires and explosions from processing and finishing aluminum and aluminum alloys were tentatively adopted by the NFPA in 1955.[55]

Dust clouds of aluminum can explode with great violence. The danger of dust explosions in aluminum powder factories is diminished by retarding oxidation and other fire protection principles set forth in the NFPA Aluminum Bronze Powder Code.[54]

Explosions in polishing mills have been attributed to static spark ignition of the stream of aluminum powder leaving the polishing machine. Experiments have shown that potential differences of up to 3000 volts are possible in a polishing mill. One explosion occurred 90 seconds after a new mill had been set in operation, excluding the possibility of ignition by heat.

Aluminum with Halogen Compounds

When aluminum is in contact with carbon tetrachloride, or a mixture of CCl_4 and chloroform (as is found in fire extinguishers), or methyl chloride (used in some refrigerators), it is capable of producing an explosion under certain conditions. Methyl chloride may form the spontaneously flammable aluminum methyl when in contact with solid aluminum.[56] Clouds of aluminum and magnesium can be exploded in an atmosphere of Freon.[66]

Aluminum — Heat Treating

Although solid aluminum is commonly heat treated in molten nitrate baths (under carefully controlled conditions) aluminum-magnesium alloys have caused explosions when accidentally introduced into such baths.

Aluminum — Fire Prevention

Aluminum powder, in any form, should be kept in tightly covered containers in a location where it will not become wet. Containers of both the paste and powder should be kept in a warm, dry, fire-resistive room, at a temperature between 60°F. and 80°F., and at least three feet from radiators and steam pipes.[57]

Aluminum paste and powder should also be stored separately from oxidizing materials (with which it may form a high explosive), from alkaline caustic solutions, and from acids (which, like water, will cause the generation of hydrogen, but to a greater extent), from chlorine, bromine and other halogens (which may cause spontaneous ignition), and from flammable liquids and other readily combustible materials (which, if ignited, may cause involvement of the aluminum powder).

Aluminum — Fire Fighting

Aluminum powder is capable of producing a dangerous reaction with water, carbonates, carbon dioxide, foam, Freon and carbon tetrachloride, and therefore these materials are not recommended as extinguishing agents, although water may be effectively applied by experienced fire fighters where only solid aluminum (and not powder) is involved.

Fires in aluminum powder are best extinguished by sand, salt (sodium chloride), talc or other dry inert material applied gently to smother the fire. Extreme care should be used not to disturb the dust, as is illustrated by the case of the employee who, instead of "ringing" the small pile of burning aluminum powder, dropped the sand directly on top of it, causing the powder to fly into the open

door of a nearby incinerator. The resulting explosion blew him fifty feet away and stripped him of his clothes.

Some fire fighters have reported successful extinguishment of small aluminum powder or chip fires by pouring oil over the fire, and then putting out the oil fire with any agent suitable for oil fires.

Metals — Magnesium

What has been said about aluminum powder hazards and reactions is also true of magnesium, except that magnesium, weighing about two-thirds as much as aluminum, is generally recognized as being more dangerous in many respects, and its fire aspects have probably been more extensively studied.

Not only should firemen know where magnesium is being locally used or stored, but also what form it is in. The form is particularly important in the event of fire.

Pure magnesium melts at 1204°F., and though its ignition temperature (1000°F. to 1200°F. for the solid form) is usually lower than its melting point, solid pieces will melt faster than they burn. If involved in fire, shavings and scrap, though more easily ignited, will not produce as much molten metal as will large ingots and castings which rapidly absorb heat. In the latter case the burning takes place on the surface of the molten material.

The safeguards to be applied in the manufacturing of magnesium powder are presented in the NFPA Magnesium Powder or Dust Code.[58]

As slightly moist magnesium is extremely hazardous from the standpoint of generation of hydrogen, all dust collection equipment should be frequently checked to make sure that the water level is properly maintained. Hydrogen may still be formed, but the submerged powder will not burn. Inspection of one piece of such equipment following an explosion that occurred while an employee was filing down a grinding wheel, revealed that the water had almost all evaporated, and a crust had formed inside the collector above the previous water level.

Magnesium sludge from collectors should be allowed to remain under the water about 12 hours, and upon removal be burned in a segregated area at a safe distance from combustible material. Details of sludge disposal are published in the NFPA Magnesium Standards.[59]

Magnesium — Fire Protection

In the matter of fire protection for magnesium occupancies, the following precautions are recommended:

1. Noncombustible, one-story construction with ample venting area.

2. Automatic sprinkler protection (except in plants where magnesium powder constitutes the principal fire hazard).

3. Prompt collection and proper storage (in tightly sealed metal containers) of magnesium scrap, shavings or dust.

4. Exclusion of combustible materials from magnesium work areas.

5. Special extinguishing agents for use on small magnesium fires.

Magnesium — Fire Fighting

In the initial size-up of magnesium fires, a close approach can usually be made, for magnesium burning without the application of water is no more dangerous than burning wood. Although

temperatures approaching 2500°F. may be reached, it gives off less heat per pound than soft coal, and about one-half that of gasoline, and only slightly more than soft pine wood. It does not give off toxic gases, as the dense white smoke is ash (magnesium oxide).

Since magnesium that has started burning has very little salvage value, it may often be preferable to let it burn and devote major attention to preventing a spread of the fire to other magnesium piles and to the building.

On small fires involving magnesium, proprietary compounds, consisting of sodium chloride, resins, graphite, etc., may be used, or the burning material can be picked up on a dry shovel and carried outside. Where magnesium fires occur in furnaces, the fire cannot be extinguished by completely shutting up the furnace, for when it has used up all the available oxygen, it will continue to burn in the remaining nitrogen. Although the use of sulfur dioxide in the furnace may tend to inhibit ignition of the magnesium, it will nevertheless support its combustion if ignition takes place.

Tests indicate that if scrap magnesium is dry and in sealed drums there is no danger of the drums bursting or exploding, as the burning of the magnesium in such case tends to produce a vacuum in the drum rather than any pressure. However, if the scrap is oily, the vaporization of the oil may build up pressure in a tight container. This may be prevented by keeping the drums cool with water.[60]

The above tests also emphasized the hazard of applying hose streams to open piles of burning scrap and turnings. At the start, minor blasts or explosions were produced with spattering of burning particles. As the extinguishing operations progressed these became more vigorous, until about 9 minutes later a violent explosion occurred which scattered chunks of the metal weighing up to 60 pounds as far as 275 feet. The force of the above described explosion was attributed to molten magnesium coming in sudden contact with a puddle of water.

Where the scrap fire was in open drums, there was a showering of sparks when the hose streams hit. Such fires could not be put out with hose streams.

In Los Angeles, water applied in large quantities was effective in bringing about complete control and extinguishment of a magnesium fire. More than four tons of magnesium castings in the fire area were saved, and owing to an early collapse of the wood roof on the building, the heavy explosions which resulted when large streams hit the molten metal did little further damage. In such cases it is desirable to ventilate the building as much as possible before applying water.

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Carbon Dioxide Fire Protection

by Dr. Charles A. Goetz

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Carbon dioxide at ambient temperature and pressure is a gas. When the gas is compressed and cooled sufficiently it becomes a liquid. It is as a liquid that carbon dioxide is stored for fire protection use, whether it be in a portable fire extinguisher, a bank of high pressure cylinders or in a refrigerated low pressure storage tank.

Figure 1 shows the pressure exerted by liquid carbon dioxide at various temperatures. The curve has been plotted with the assumption that there is some gaseous carbon dioxide on top of the liquid in the vessel. If the vessel were completely full of liquid, the pressure would increase very rapidly as the temperature rose and would not follow the gradual curve. For this reason carbon dioxide vessels are not filled completely with liquid.

This article is based upon a talk presented by Dr. Goetz at the 59th NFPA Annual Meeting held May 16-20, 1955 in Cincinnati, Ohio. - Ed.

The Combustion Reaction

For a proper evaluation of the uses and limitations of carbon dioxide as an extinguishing agent a review of the combustion reaction will be useful.

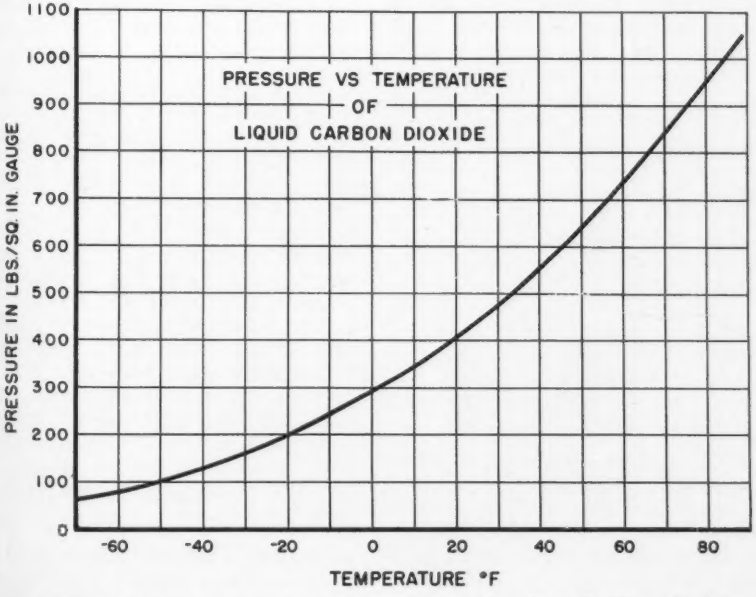

Figure 1. Variation of pressure in a container of carbon dioxide with change of temperature.

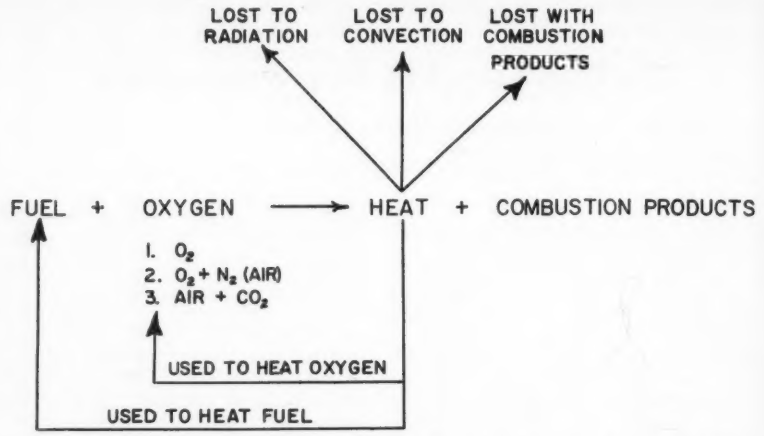

Figure 2. A heat balance is necessary for fire to continue to burn. Upsetting this balance by the removal of more heat from the fire zone than is generated by the combustion reaction causes the fire to go out.

Figure 2 shows that when fuel is heated to its ignition temperature in the presence of oxygen the fuel is burned and heat and combustion products are formed. For the fire to maintain itself the heat generated has to be sufficient to do several things: (1) to heat the fuel entering the fire zone to its ignition temperature, (2) to heat the oxygen (or air) and (3) to compensate for wasted heat. Wasted heat is that which is removed from the fire area by radiation, convection, and by the hot products of combustion. Every camper knows that his fire must be laid to minimize the amount of heat lost in these three ways. If two sticks of wood are far apart large amounts of heat can radiate away and be lost. Bringing the sticks together reduces the heat lost by radiation.

When air passing through the fire zone is heated up but does not contribute to the burning, heat is lost by convection. For example, air passing between two sticks that are not close together will get hot but only a small part of the oxygen in the air will be able to combine with the fuel and create more heat. With the sticks closer together more of the oxygen in the air has a chance to react with the fuel and consequently less heat is lost by convection.

In fire extinguishment the basic task is to absorb, use or lose more heat than is generated, thus upsetting the heat balance and cooling the fire. To understand how this is accomplished with water, consider the difficulty in burning wet wood where enough heat is absorbed in converting the water to steam to cool the fuel to below its ignition point. If pure oxygen were substituted for air the fire would probably burn briskly because, although the same amount of heat would be used in converting the water to steam, heat would not be used to heat up inert nitrogen (79 per cent of the air is nitrogen). Ordinarily, heated nitrogen removes a considerable amount of heat from the fire area.

Air is not ordinarily considered to be an extinguishing agent but is frequently used for this purpose. Why can a lighted match be blown out? One ex-

planation is that the large volume of air that is blown through the fire zone absorbs so much heat that the fire goes out.

Fire can also be extinguished by using carbon dioxide or some other inert gas to dilute the 21 per cent oxygen concentration in the air. This diluted mixture will require more heat to raise a given amount of oxygen to the combustion temperature, and the diluted oxygen will result in less perfect combustion.

Uses of Carbon Dioxide

Carbon dioxide protection is recognized by most people as being particularly applicable to flammable liquid and gas fires. Another application that has become well established is the protection of electrical units such as transformers, circuit breakers and rotating equipment. Protection of the fire hazard associated with combustible fuel engines is a third use of carbon dioxide.

Although many people are apt to doubt the wisdom of using carbon dioxide on paper or textile fires, research has shown that under properly engineered conditions it is very effective.

Limitations

Carbon dioxide is not a cure-all for every kind of hazard under every kind of condition. It does have its limitations, as do all other fire extinguishing agents. Fire involving chemicals containing their own oxygen supply, e.g., cellulose nitrate, usually cannot be extinguished by carbon dioxide since in these instances displacement of air does not eliminate all sources of oxygen from the fire area. However, even fires in oxygen-containing materials can under certain conditions be put out by the rapid cooling of carbon dioxide.

Carbon dioxide should not be used on fires involving active metals such as sodium and magnesium nor on metal hydride fires. When these materials burn very high temperatures are developed which break down carbon dioxide

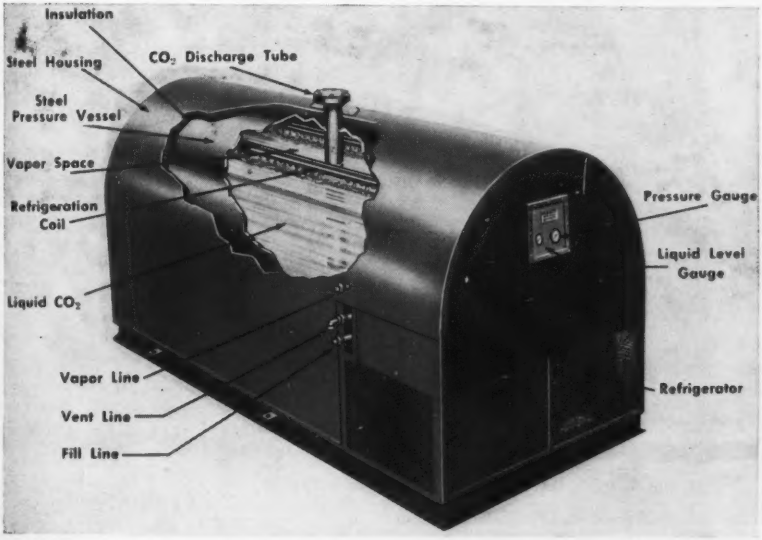

Figure 3. Details of a storage tank for a low pressure carbon dioxide system.

to carbon monoxide and oxygen, and sufficient heat continues to be generated to sustain the fire. It is true that under certain total flooding conditions where the carbon dioxide discharge velocity is very low, a metal fire can be put out by the coating of solid metal carbonate that forms. This use of carbon dioxide demands careful engineering and is restricted by several limitations.

Low and High Pressure Systems

In a low pressure carbon dioxide system the carbon dioxide is stored in a refrigerated container as a liquid at approximately 0°F. and 300 psi. High pressure carbon dioxide is stored as a liquid at room temperature and, as indicated by Figure 1, the pressure is consequently considerably higher. At 70°F. the pressure is about 840 psi.

Figure 3 shows the details of a low pressure storage tank. Not shown, but located in the housing end of the tank above the refrigerator, are safety release valves that discharge into the vent line. As heat enters the pressure vessel through the insulation the pressure in the vessel gradually rises. An increase of about 10 psi causes the refrigerator to start, which pumps heat out of the vessel until the pressure is again reduced to normal.

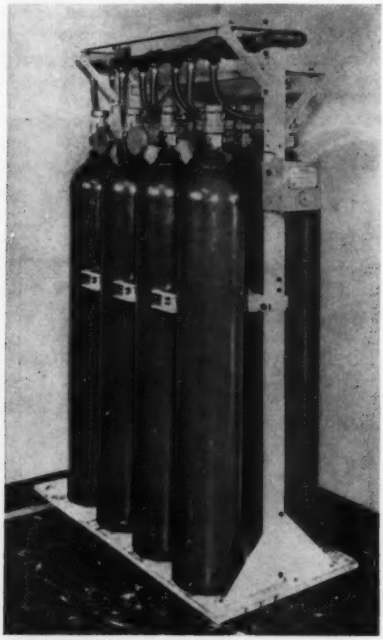

Figure 4. A bank of storage cylinders for a high pressure carbon dioxide system.

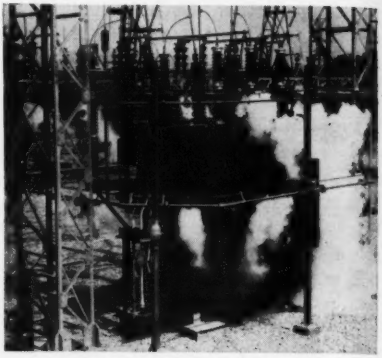

Figure 5. Local application of carbon dioxide by a fixed system protects this electrical transformer. When this photo was taken the carbon dioxide had been turned on and the cloud of gas had started to encompass, by local application, this large potential fire zone.

Varying numbers of carbon dioxide cylinders can be manifolded together depending on the amount of carbon dioxide required to protect a hazard (see Figure 4). As previously indicated these cylinders are never completely filled. Each is equipped with a dip tube reaching to the bottom so that carbon dioxide will always be discharged as a liquid. Were there no dip tube, gaseous carbon dioxide would be released, heat of vaporization would cause the temperature in the vessel to become progressively lower and eventually the liquid remaining in the cylinder would freeze to dry ice.

Local Application

Extinguishment of a gasoline spill with a portable carbon dioxide extin-

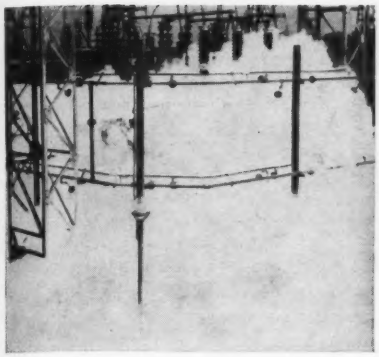

Figure 6. The transformer shown in Figure 5 was completely enveloped in a cloud of carbon dioxide when this photo was taken.

guisher is an example of local application. In this method the carbon dioxide is applied directly to the fire zone. During the past 15 years much work has been done in developing techniques for the use of the local application method with the result that today local application by small capacity hand extinguishers has been supplemented by large capacity hand applications and fixed systems. Protection of an outdoor electrical transformer as shown in Figures 5 and 6 is an example of large scale local application.

The quantity of carbon dioxide needed in the local application method can be calculated on the basis of the amount that must be applied to the surface of a fire zone to cover completely any area that may be involved in a fire. Another approach to the quantity requirements is to assume a mythical cube and create in that cubed area a sufficiently high concentration of carbon dioxide to extinguish a fire in that cube.

Total Flooding

Extinguishment by total flooding consists of discharging carbon dioxide into an enclosed space about a hazard. This type of system may be used where there is a permanent enclosure about the hazard that is adequate to enable the required concentration to be built up, and to be maintained long enough to insure permanent extinguishment.

As shown in Table 1, recommended concentration of carbon dioxide depends upon the combustible material. In the case of a methane fire, dilution of the air until the carbon dioxide concentration is 30 per cent will cause the fire to go out; for kerosene 34 per cent, ethane 40 per cent. The recommended concentrations in Table 1 were set by the NFPA Committee on Carbon Dioxide Extinguishing Systems and contain a safety factor. The theoretical concentrations to cause extinguishment are actually lower.

Table 1. Recommended Carbon Dioxide Concentrations for Extinguishment

Combustible Material	Advocated CO_2 Concentration %
Methane	30
Kerosene, Gasoline	34
Ethane	40
Ethanol	43
Ethylene	49
Acetylene	66
Paper, Rags	75

When determining the amount of carbon dioxide required to reach a certain concentration in an enclosure it must be remembered that while the carbon dioxide is being injected "free egress" is taking place whereby an increasing amount of carbon dioxide is usually escaping from the enclosure. At first only air would leave the enclosure, but gradually as the carbon dioxide concentration in the enclosure is increased by "progressive mixing" the gas mixture leaving would be richer in carbon dioxide.

How to obtain a given concentration of carbon dioxide, taking into consideration "free egress" and "progressive mixing" is shown in Figure 7. Using the solid curve it will be found that when five pounds of carbon dioxide per 100 cubic feet of enclosure space

have been added, a concentration of approximately 35 per cent is obtained. A 50 per cent concentration would require about eight pounds of carbon dioxide per 100 cubic feet and an 80 per cent concentration 20 pounds.

Under certain conditions it is possible to apply carbon dioxide to an enclosure so that substantially all of the gas leaving the enclosure by free egress is air. Suppose carbon dioxide were injected into a fur vault at floor level and the only escape for the air was at ceiling level. With such an arrangement very little carbon dioxide would escape by free egress and the required high concentration could be reached using much less carbon dioxide than would have been required had progressive mixing taken place. (Compare the broken and solid lines in Figure 7.)

It should be pointed out that extinguishment is dependent not only upon the concentration of carbon dioxide, but also upon the length of time that the concentration must be maintained in the fire zone. Since larger quantities of heat can be lost readily from surface fires by radiation and convection, surface fires are, relatively speaking, easy to extinguish promptly. The length of time that the surface fire has been burning prior to discharge of carbon dioxide also influences the ease of extinguishment. When a flammable liquid fire is detected automatically and the carbon dioxide is discharged within a minute of the ignition, extinguishment is just a matter of discharging the required amount of carbon dioxide into a fire area and allowing it to dissipate

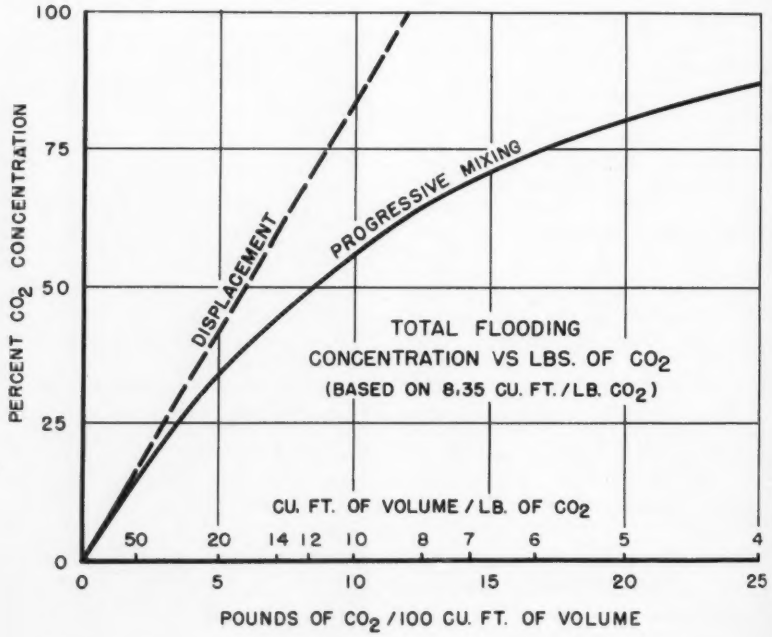

Figure 7. Curve used to determine the amount of carbon dioxide required to reach different concentrations.

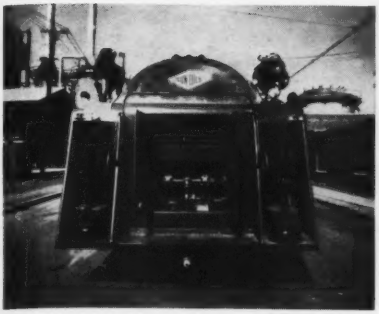

Figure 8. This mobile unit carries a three-ton low pressure storage tank. The 1½-inch hose lines are used primarily for direct local application but under certain conditions may be used for total flooding. Quick change couplings make it possible to change from direct application nozzles to special bayonet total flooding nozzles, or to connect to a standpipe.

Figure 9. The mobile supply on this unit consists of high pressure cylinders. The hose line with nozzle can be used for local application or for totally flooding an enclosure. It can also be used to supply a carbon dioxide standpipe.

through normal leakage. But if there has been a long period of burning during which a large quantity of heat has been generated, the required concentration of carbon dioxide to actually stop the burning may have to be maintained in the space for a considerable time until the stored heat can escape and until the hot combustible material has cooled to below its ignition temperature.

Deep-seated fires require maintenance of the carbon dioxide concentration for extended periods. Were a fire to start in the midst of a rack of fur coats in a fur storage vault it would probably burn at a low rate for a long period (unless a suitable detection system was provided) building up deeply embedded high temperatures. Discharge of carbon dioxide will stop the burning when the required concentration is reached but unless the concentration is maintained, reignition is probable since a considerable time will elapse before enough heat has escaped to reduce the temperature below the ignition point of the coats.

Mobile Equipment

In the 1955 tentative revision of the NFPA Standard on Carbon Dioxide Extinguishing Systems, Chapter 5 is devoted to Standpipe Systems and Mobile Supply. These systems consist of a mobile supply of carbon dioxide capable of being moved quickly to position and either connected to a system of fixed piping supplying fixed nozzles or to hose lines that may be used for total flooding or for local application. Standpipe systems and mobile supply may be used to supplement complete fixed fire protection systems or may be used alone for the protection of specific hazards.

Fires and Fire Losses Classified, 1954

There were approximately 1,993,000 fires of all types in the United States in 1954, causing a loss of $1,017,000,000. According to estimates compiled by the National Fire Protection Association, the 1954 loss was a decrease of approximately $5,000,000 from the $1,021,720,000 estimated loss of 1953.*

Building fires in the United States in 1954 totalled 774,600 and caused $875,450,000 damage. An additional 1,218,700 fires not involving buildings — aircraft, motor vehicles, forest, ships, rubbish, grass fires, etc. — accounted for an estimated $141,465,000. Building fire estimates for 1953, reported in the October 1954 QUARTERLY, showed 727,000 fires with $889,120,000 loss.

The number of building fires for 1954 has increased 6.1 per cent over 1953 figures, while the loss of 1954 is 1.5 per cent less than the previous year.

The data from which Tables I to IV were compiled were obtained from 20 state fire marshals' reports for the year 1954 or the closest fiscal year thereto. The states chosen for inclusion in each of the four tables were selected because of the relative accuracy of their statistics and the completeness of the occupancy and cause classifications. This year 22 states submitted a summary of their annual fire experience, the largest number of states ever to report. The increase in the number of states that submit annual reports is gratifying.

While the methods of reporting and tabulating fire loss figures differ from state to state, the volume of statistics from the 20 typical states chosen, representing all sections of the country and including both primarily agricultural and industrial states, is sufficiently large to indicate the relative distribution of fires and fire losses. Table I shows the number of fires by occupancy in 13 states and Table II the loss by occupancy in 14 states. Tables III and IV list the number of fires and loss by cause in 14 and 12 states respectively. Table V summarizes statistics from all state reports received.

Tables VI and VII, showing the nation-wide distribution of fires and losses by occupancy and cause, are based primarily on typical state experience enumerated in Tables I to IV.

Various sources have furnished figures for items in Table VI. Railroad losses were furnished by the Association of American Railroads, Fire Protection and Insurance Section. Statistics on aircraft fires were compiled by the NFPA Committee on Aviation and Airport Fire Protection. Motor vehicle data are based on a recent survey of 577 U. S. cities (Fire Record of Cities, April, 1955 QUARTERLY). The estimate of the number of forest fires was compiled by the Forest Service of the U. S. Department of Agriculture.

(Continued on Page 191)

*The 1953 estimate included a $45,000,000 loss at one industrial fire.

TABLE I. Number of Fires by Occupancies in Thirteen States — 1954

Occupancies	Del.	Iowa[4]	Kansas	Ky.[1]	La.	Mont.	Nebr.	N. H.	N. Dak.[1,3]	Okla.	Ore.[1]	S. Dak.[2]	Wisc.[1]	Totals
I. PUBLIC BUILDINGS														
Government buildings	...	4	4	6	...	2	5	...	27	...	32	1	17	98
Hospitals, institutions	...	5	6	13	22g	3	3	9	3g	7	...	1	44	116
Schools and colleges	2	15	24	49	52	9	10	8	10	22	41	11	186	439
Churches	3	21	18	30	39	2	12	6	13	17	29	3	117	309
Theatres, including motion pictures	6	4	7	41	17	2	2	1	...	12	11	...	17	120
Amusement, halls	...	19	15	...	...	8	24	9	...	...	...	2	98	175
II. RESIDENTIAL														
Hotels	8	40	27d	53a	310a,d	32	18	17	54	141k	307b	46k	128	1,181
Boarding and rooming houses	16	17c	19c	...	...	9	83i	4	...	145	...	...	46	339
Apartments	177	178	111	60b	...	33	...	56	...	...	...	29	253	906
Dwellings	754	1,616	1,326	4,685	3,298	470	615	792	817i	965	11,567i	398	29,134	56,437
III. MERCANTILE														
Offices, banks	13	34	34	78	326	2	20	...	...	12	...	6	76	601
Restaurants, taverns	27	72	54	92	...	43	22	22	...	...	111	14	784	1,241
Miscellaneous mercantiles	120	163	233	315	...	73	80	69	145	87	571l	98m	1,150	3,104
Warehouses	15	40	47	22	98	4	22	6	17	46	11	3	170	501
IV. MANUFACTURING														
Metalworkers	...	25	21	19	12	3	1	2	3	...	24	...	46	156
Woodworkers	...	13	6	7	30	...	...	18	7	...	145	...	9	235
Grain mills, elevators	...	64	7	12	3	1	28	...	13	...	12	10	118	268
Food Processing	...	28	8	12	33	...	2	1	5	...	27	...	14	130
Bakeries	...	6	...	3	...	3	...	...	...	...	9	...	29	50
Textile workers	...	5	4	...	61	...	...	...	2j	6	1	...	6	85
Printing	...	6	4	3	...	1	1	3	...	...	9	1	23	51
Laundries	...	9	8	26e	...	6	...	2	...	17	18e	...	19	105
Cleaners, tailors	1	5	...	...	...	...	9j	1	...	9	...	4	40	69
Miscellaneous manufacturing	220	21	12	55	21	2	25	31	7	34	26	16	412	882
V. MISCELLANEOUS														
Barns	...	242	331	341	168h	6	287h	42	316h	51	241h	149	1,831	4,005
Outbuildings	76	119	...	62	...	6	134	99	...	...	...	9	590	1,095
Lumber and coal yards	...	52	7	17	23	1	6	...	4	10	...	2	17	139
Piers, including shipyards	...	...	...	3	...	...	...	...	...	...	...	...	...	3
Railroad property, inc. rolling stock	...	29	14	3	...	...	...	1	...	...	...	...	355	402
Bulk oil storage, refineries	...	5	9	12	65	3	3	...	2	...	...	...	...	99
Garages	11	315	12	75f	...	33	26	13	33	171	38	72	410	1,199
Filling stations	2	31	21	...	...	13	...	6	...	36	24	...	62	195
Power plants, pump houses	...	9	4	12	45	...	5	...	2	...	21	...	59	157
Creameries and dairies	...	6	3	5	...	1	2	2	...	...	5	...	88	112
Miscellaneous structures	2	191	21	6	189	53	25	13	2	321	20	7	517	1,367
VI. OTHER THAN BUILDING FIRES														
Aircraft	...	...	1	...	...	...	...	...	...	...	...	...	1	2
Motor vehicles	325	550	364	250	558	...	229	...	...	951	617	107	1,462	5,413
Forest fires	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rubbish, grass, brush	1,136	6	...	...	...	...	144	...	...	...	...	125	...	1,411
Miscellaneous	819	177	15	147	...	8	114	9	...	4,001	5	53	5,473	10,821
Totals	3,733	4,142	2,797	6,532	5,360	832	1,957	1,242	1,482	7,061	13,912	1,167	43,801	94,018

f Insured losses only.
[2] Fiscal year ended June 30, 1954.
[3] Fiscal year ended June 30, 1955.
[4] Fiscal year ended August 31, 1954.

a. Includes boarding houses.
b. Includes rooming houses.
c. Includes fraternity and sorority houses.
d. Includes clubs.
e. Includes dry cleaning.
f. Includes filling stations.
g. Includes government buildings.
h. Includes farm property, livestock, crops, hay.
i. Includes apartments.
j. Includes laundries.
k. Includes restaurants.
l. Includes offices.
m. Includes warehouses.

TABLE II. Fire Losses by Occupancies in Fourteen States — 1954

Occupancies	Conn.[1]	Illinois[2]	Iowa[4]	Kansas	Ky.[1]	La.	Minn.[7]	Nebr.	N.Dak.[1,2]	Ohio	Ore.[3]	S.Dak.[5]	W.Va.[6]	Wisc.[1]	Totals
I. Public Buildings															
Government buildings	.....	$50,015	$3,750	$295	$14,810	.....	.....	$80,325	$68,196	.....	$10,784	$301	$2,250	$1,849	$232,575
Hospitals, institutions	.....	45,592	1,569	4,270	9,503	$23,885g	$55,342	2,136	941g	$92,496	.....	13,422	2,311	23,070	274,537
Schools and colleges	$479,285	659,423	39,390	259,344	189,632	247,546	430,243	47,935	7,597	115,130	146,408	229,220	16,150	182,852	3,050,155
Churches	77,499	791,175	274,696	49,178	194,557	111,235	183,883	422,395	41,046	1,453,443	83,950	55,788	73,168	234,230	4,046,243
Theatres, including motion pictures	663	119,657	36,898	39,435	61,212	180,186	.....	836	.....	17,565	15,147	.....	10,585	4,829	487,013
Amusement, halls	119,569	227,352	191,293	91,470	.....	.....	286,587	104,305	.....	207,279	.....	15,481	.....	127,575	1,370,911
II. Residential															
Hotels	138,236	371,512a	37,039	15,513d	60,456a	512,904a,d	141,531	19,680	116,683	116,419	156,414b	22,584k	10,246a	112,924	1,832,141
Boarding and rooming houses	40,577	.....	3,669c	8,864c	.....	.....	269,676i	60,240i	.....	.....	.....	.....	.....	8,245	391,271
Apartments	251,853	4,055,385b	149,684	191,133	129,474b	.....	.....	.....	.....	879,050b	.....	19,773	200,837	137,496	6,014,477
Dwellings	1,518,985	6,800,667	2,360,084	1,404,140	7,080,523	3,572,322	1,988,221	1,055,571	395,509i	7,110,587	4,287,217i	418,505	1,626,943	5,912,403	4,553,677
III. Mercantile															
Offices, banks	233,585	272,290	190,843	123,925	239,491	658,242	158,463	27,042	.....	85,517	.....	14,562	28,268	66,032	2,098,260
Restaurants, taverns	225,062	1,423,560	169,574	162,753	289,545	.....	964,329	55,578	.....	.....	246,480	89,964	148,771	719,467	4,495,083
Miscellaneous mercantiles	582,601	4,966,698	1,709,472	1,635,336	1,387,060	.....	1,518,148	1,004,116	381,140	.....	1,800,279l	527,590m	1,308,054	1,617,656	18,438,152
Warehouses	169,933	1,301,101	345,600	94,882	161,760	619,667	162,267	458,330	42,274	3,567,204	26,636	5,311	119,000	873,237	7,947,202
IV. Manufacturing															
Metalworkers	1,600	63,544	79,374	108,909	55,453	128,179	.....	1,200	99,933	.....	21,070	.....	500	199,763	759,525
Woodworkers	13,128	219,457	21,239	14,722	7,175	716,884	.....	.....	15,078	.....	1,845,251	.....	482,510	49,957	3,385,401
Grain mills, elevators	.....	328,058	591,366	79,130	1,035,263	7,296	208,694	458,673	603,579	.....	189,979	355,870	.....	79,845	3,937,753
Food Processing	.....	1,100	121,541	9,510	65,218	153,272	.....	172,000	7,629	.....	58,531	.....	6,750	22,652	617,384
Bakeries	15,631	16,005	81,610	.....	8,989	.....	56,500	.....	.....	.....	2,250	.....	70	6,948	188,003
Textile workers	315	.....	24,135	9,675	.....	240,832	.....	.....	1,084j	.....	72	.....	.....	2,841	278,954
Printing	2,500	.....	6,099	2,000	2,730	.....	.....	100	.....	.....	2,648	130	4,025	10,340	30,542
Laundries	510	302,849	4,510	845	27,036e	.....	41,707e	.....	.....	272,201	20,112e	.....	.....	4,481	674,251
Cleaners, tailors	21,546	72,248	3,702	.....	.....	.....	3,780	1,688j	.....	41,804	.....	39,508	25,350j	8,869	218,495
Miscellaneous manufacturing	457,299	4,209,439	524,648	72,080	696,508	132,420	1,978,401	203,714	7,710	2,825,934	242,871	61,444	848,349	1,232,112	13,492,929
V. Miscellaneous															
Barns	402,199	1,963,787	1,239,133	1,120,439	707,849	268,472h	684,801	695,655h	633,851h	3,624,218	464,437h	247,798	155,225	2,848,917	15,056,781
Outbuildings	.....	.....	113,202	.....	77,102	.....	365,627	118,566	.....	318,699	.....	4,070	96,210	89,027	1,182,503
Lumber and coal yards	110,443	362,247	123,812	65,171	131,271	331,092	27,177	210,125	18,047	928,195	.....	5,775	133,300	78,761	2,525,416
Piers, including shipyards	.....	.....	.....	.....	6,359	.....	.....	.....	.....	.....	.....	.....	.....	.....	6,359
Railroad property, inc. rolling stock	.....	.....	228,714	15,055	682	.....	.....	.....	.....	.....	.....	.....	13,350	32,730	290,540
Bulk oil storage, refineries	.....	17,505	8,932	59,220	16,684	554,264	500	4,635	65,552	.....	.....	.....	66,250	.....	793,542
Garages	155,943	2,842,730	235,882	55,966	367,250f	.....	136,007f	280,021	41,643	735,213f	34,886	89,112	128,847	279,023	5,382,523
Filling stations	25,896	140,608	93,619	26,497	.....	.....	.....	.....	.....	.....	19,415	.....	28,750	52,594	387,399
Power plants, pump houses	.....	9,975	15,892	13,819	28,470	586,353	17,768	19,875	4,557	.....	84,426	.....	.....	119,246	900,381
Creameries and dairies	.....	.....	21,722	25,738	28,882	.....	65,445	1,580	.....	.....	43,094	.....	.....	83,541	270,002
Miscellaneous structures	48,160	2,883,316	220,529	355,184	25,005	556,986	205,215	284,690	6,098	3,902,276	48,100	46,325	238,617	371,690	9,192,191
VI. Other Than Building Fires															
Aircraft	.....	.....	.....	400	.....	.....	.....	.....	.....	.....	.....	.....	6,000	1,025	7,425
Motor vehicles	38,717	602,249	152,507	69,739	165,016	239,911	70,212	152,932	.....	628,705	129,518	47,457	122,277	258,273	2,677,513
Forest fires	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rubbish, grass, brush	.....	.....	760	.....	.....	.....	.....	70,131	.....	.....	.....	57,413	.....	.....	128,304
Miscellaneous	620,502	164,090	76,179	2,600	106,037	.....	140,585	120,219	.....	18,724	19,401	80,853	246,335	792,516	2,388,043
Totals	$5,752,037	$35,283,634	$9,502,638	$6,187,227	$13,377,008	$9,841,948	$10,161,109	$6,134,293	$2,558,147	$26,940,659	$9,999,376	$2,448,262	$6,149,288	$16,647,019	$160,982,645

[1] Insured losses only.
[2] Fiscal year ended June 30, 1954.
[3] Actual losses where claims were made.
[4] Fiscal year ended August 31, 1954.
[5] Fiscal year ended June 30, 1955.
[6] No losses less than $50.
[7] No losses less than $25.
a. Includes boarding houses.
b. Includes rooming houses.
c. Includes fraternity and sorority houses.
d. Includes clubs.
e. Includes dry cleaning.
f. Includes filling stations.
g. Includes Government buildings.
h. Includes farm property, livestock, crops, hay.
i. Includes apartments.
j. Includes laundries.
k. Includes restaurants.
l. Includes offices.
m. Includes warehouses.

TABLE III. Number of Fires by Causes in Fourteen States — 1954

Causes	Iowa [5]	Kansas	Ky. [1]	La.	Mich.	Mont.	Nebr	N.H.	N.D. [1,2]	Okla.	Ore. [1]	R.I. [3,6]	S.D. [4]	Wisc. [1]	Totals
Chimneys, flues — defective or overheated	146	60	429	76	1,569	45	77	122	70	33	838	72	37	289	3,863
Sparks on roof	159	13	48	...	631	...	...	...	...	...	176	...	...	...	1,027
Defective or overheated heating and cooking equipment:															
Oil-fired equipment	124	...	...	228	2,700	...	...	38	...	...	...	109	48	1,360	4,607
Gas-fired equipment	5	...	...	217	...	...	...	...	64	...	...	...	4	204	494
Other and unknown	274	194	453	57	3,700	82	184	172	120	341	1,178	65	88	1,540	8,448
Rubbish, ignition unknown	...	180	135	182	5,918	15	178	18	...	571	51	50	89	148	7,535
Combustibles near heaters	66	...	...	...	...	8	11	6	...	...	...	...	...	350	441
Open lights, flames, sparks	25	73	51	277	410	15	62	9	71	...	192	39	63	890	2,177
Hot ashes, coals	30	32	69	...	209	...	11	2	...	...	1,102	2	11	129	1,597
Smoking and matches	411	250	663	717	4,194	98	204	203	232	421	3,694	74	109	5,925	17,195
Children and matches	148	...	...	...	...	49	66	33	...	229	...	33	59	455	1,072
Electrical, fixed services, fires due to misuse, or faulty wiring and equipment	269	299	817	741a	1,984	91	207	160	200a	371	1,147	118	107	2,014	8,525
Electrical, power consuming appliances	298	26	58	...	2,565	5	86	57	...	55	1,274	1	46	1,993	6,464
Flammable liquids, misuse of including vapor explosions, grease, tar, etc.	132	155	195	...	527	95	159	72	...	121	2,165	39	33	1,762	5,455
Flammable liquid appliances, including lamps, blow torches, salamanders, etc.	14	...	...	...	...	...	2	3	...	...	...	...	10	96	125
Torches, welding and cutting	66	...	...	34	...	5	43	15	4	...	...	...	17	64	248
Gas and appliances, including gas explosions	21	39	62	...	482	...	12	10	...	...	...	11	9	59	705
Spontaneous ignition	74	15	45	17	2,332	27	65	27	16	69	122	13	29	205	3,056
Lightning	195	92	1,202	281	911	16	111	150	115	27	52	8	54	22,745	25,959
Thawing pipes	18	...	...	...	...	10	...	...	...	...	...	...	...	10	38
Sparks from machinery, friction	48	4	41	41	...	2	12	10	13	...	66	...	...	37	274
Incendiary, suspicious	26	16	8	132	763	3	17	14	1	...	55	46	4	59	1,144
Miscellaneous	761	163	11	200	19,365	20	46	32	132	506	12	163	116	1,759	23,286
Unknown	652	1,002	1,861	1,722	6,178	216	341	47	385	4,317	1,442	240	136	920	19,459
Explosions, miscellaneous and unclassified	...	55	168	...	...	6	2	...	...	...	58	...	26	561	876
Exposure	180	129	216	438	290	24	61	42	59	...	288	27	72	227	2,053
Totals	4,142	2,797	6,532	5,360	54,728	832	1,957	1,242	1,482	7,061	13,912	1,110	1,167	43,801	146,123

[1] Insured losses only.
[2] Fiscal year ended June 30, 1954.
[3] Fiscal year ended Sept. 30, 1954.
[4] Fiscal year ended June 30, 1955.
[5] Fiscal year ended August 31 ,1954.
[6] There were an additional 584 insured loss fires not reported to the State Fire Marshal.
a. Includes electrical appliances.

TABLE IV. Fire Losses by Causes in Twelve States — 1954

Causes	Conn.[5]	Illinois[2]	Iowa[4]	Kansas	Kentucky[1]	Louisiana	Nebraska	Ohio	Oregon[3]	South Dakota[5]	West Virginia[6]	Wisconsin[1]	Totals
Chimneys, flues — defective or overheated	$104,678	$1,032,243	$222,706	$46,600	$919,299	$44,685	$140,348	$929,688	$376,600	$43,767	$165,555	$344,986	$4,371,155
Sparks on roof	.....	163,473	184,735	5,915	49,139	.....	.....	620,761	106,399	.....	4,200	.....	1,134,622
Defective or overheated heating and cooking equipment:													
Oil-fired equipment	322,962	.....	145,064	.....	.....	335,522	.....	.....	.....	48,075	39,814	689,649	1,581,086
Gas-fired equipment	.....	.....	144	.....	.....	288,589	.....	.....	.....	16,413	25,044	66,582	396,776
Other and unknown	57,868	1,601,702	355,357	308,834	923,836	73,528	222,906	2,002,029	676,511	140,189	512,496	923,040	7,798,296
Rubbish, ignition unknown	.....	4,275,695	.....	60,300	110,635	179,871	108,764	317,750	78,770	65,196	16,895	53,508	5,267,384
Combustibles near heaters	.....	28,403	47,119	.....	.....	.....	19,022	.....	.....	.....	58,068	53,038	205,650
Open lights, flames, sparks	191,384	341,742	9,364	161,279	68,266	222,150	103,924	545,127	34,615	55,118	75,853	524,623	2,333,445
Hot ashes, coals	9,703	236,152	29,414	7,563	61,041	.....	18,925	95,521	163,336	1,582	3,500	37,449	664,186
Smoking and matches	431,908	3,458,904	251,750	224,811	604,018	331,083	171,028	1,207,606	800,179	67,097	138,589	1,118,901	8,805,875
Children and matches	126,938	.....	119,525	.....	.....	.....	60,833	469,726	.....	65,133	.....	246,369	1,088,524
Electrical, fixed services, fires due to misuse, or faulty wiring and equipment	546,676	4,639,984	921,391	306,611	2,650,748	971,546a	620,350	3,052,163	1,666,877	232,435	832,873	2,803,632	19,245,286
Electrical, power consuming appliances	262,527	194,478	205,652	6,652	21,501	.....	169,848	466,134	234,831	313,703	4,014	719,476	2,598,816
Flammable liquids, misuse of including vapor explosions, grease, tar, etc.	98,798	1,384,209	113,283	150,800	185,775	.....	213,663	866,425	406,797	7,677	103,771	449,076	3,980,274
Flammable liquid appliances, including lamps, blow torches, salamanders, etc.	44,293	.....	13,722	.....	.....	.....	700	.....	.....	202,380	2,225	68,992	332,312
Torches, welding and cutting	.....	.....	64,689	.....	.....	34,829	81,820	81,395	.....	59,158	69,900	61,599	453,390
Gas and appliances, including gas explosions	.....	167,972	89,108	26,433	126,201	.....	26,608	504,938	.....	9,956	144,964	62,665	1,158,845
Spontaneous ignition	223,496	1,572,620	193,055	25,197	223,696	25,648	147,953	1,370,935	162,010	66,933	177,923	738,061	4,927,527
Lightning	161,033	994,938	714,874	401,671	906,249	242,040	231,706	2,499,379	12,482	82,606	134,362	2,938,760	9,320,100
Thawing pipes	20,993	.....	25,183	.....	.....	.....	.....	.....	.....	.....	4,915	25,320	76,411
Sparks from machinery, friction	.....	155,941	141,459	1,054	1,068,558	52,676	3,196	.....	640,305	.....	22,850	29,556	2,115,595
Incendiary, suspicious	225,650	436,246	61,669	39,505	45,845	395,641	16,375	549,824	699,218	2,622	167,891	587,023	2,227,509
Miscellaneous	1,000,304	1,079,574	425,059	110,178	2,888	892,661	259,894	2,364,885	11,747	58,127	14,671	882,163	7,102,151
Unknown	1,772,699	10,951,003	4,391,089	4,100,746	4,532,071	5,344,350	3,423,203	8,323,466	3,725,075	562,999	2,486,365	2,783,729	52,396,795
Explosions, miscellaneous and unclassified	78,792	801,965	.....	74,261	329,925	.....	1,249	.....	92,782	148,573	796,580	279,199	2,603,326
Exposure	71,335	1,766,390	777,227	128,817	547,317	407,129	91,978	672,907	110,842	198,523	145,970	159,623	5,078,048
Totals	$5,752,037	$35,283,634	$9,502,638	$6,187,227	$13,377,008	$9,841,948	$6,134,293	$26,940,659	$9,999,376	$2,448,262	$6,149,288	$16,647,019	$148,263,389

[1] Insured losses only.
[2] Fiscal year ended June 30, 1954.
[3] Actual losses where claims are made
[4] Fiscal year ended August 31, 1954.
[5] Fiscal year ended June 30, 1955.
[6] No losses less than $50.
a. Includes electrical appliances.

(Continued from Page 186)

As will be seen in Table V, the 22 states with a population of 68,485,000 reported a total of 189,807 fires. Experience indicates that this is somewhat under half the actual number of fires in these states. Some states, for example, do not report fires with uninsured losses, others report only fires with losses in excess of $50.

To obtain national estimates of the numbers of fires by occupancy 100 per cent was added to the numbers reported by the thirteen states shown in Table I. Making use of this figure and the population ratio, the number of fires by occupancy in the United States was calculated. Following a similar procedure with the state experience shown in Table III, national estimates of the numbers of fires by cause were obtained.

To obtain the estimated national fire loss by occupancy and cause, the population ratio was applied to the loss of the states shown in Tables II and IV. To account for losses not reported through the usual channels, 33 1/3 per cent was added as in the previous years. Further adjustment was necessary in a few instances because of unusually large property damage in individual fires.

Table V. Fires per 1000 Population and Fire Loss per Person for Twenty-Two States, 1954, as Reported by Fire Marshals

State	Population 1954 Census	No. of Fires	Fires per 1000 Pop.	Fire Loss	Fire Loss per Person
Connecticut[1]	2,251,000	1,780	0.79	$5,752,037	2.56
Delaware	373,000	3,733	10.00	1,846,728	4.95
Illinois[2]	9,239,000	16,417	1.78	35,283,634	3.82
Iowa[3]	2,644,000	4,142	1.57	9,502,638	3.60
Kansas	2,038,000	2,797	1.38	6,187,227	3.04
Kentucky[4]	3,020,000	6,532	2.16	13,377,008	4.43
Louisiana	2,987,000	5,360	1.79	9,841,948	3.26
Michigan	7,126,000	54,728	7.69	32,043,705	4.51
Minnesota[9]	3,123,000	2,872	0.92	10,161,109	3.25
Montana	635,000	832	1.31	2,195,296*a*	3.46
Nebraska	1,372,000	1,957	1.43	6,134,293	4.47
New Hampshire	533,000	1,242*a*	2.34	4,418,119*a*	8.29
North Carolina[9]	4,289,000	2,246	0.53	9,898,005	2.30
North Dakota[2,4]	638,000	1,482	2.32	2,558,147	4.01
Ohio	8,655,000	15,072	1.74	26,940,659	3.12
Oklahoma	2,274,000	7,061	3.11	4,832,620*a*	2.13
Oregon[4,5]	1,656,000	13,912	8.42	9,999,376	6.03
Rhode Island[8]	832,000	1,694	2.04	2,734,481	3.29
South Dakota[1]	669,000	1,167	1.74	2,448,262	3.66
Texas[4]	8,579,000	....	....	33,148,188	3.87
West Virginia[7]	1,950,000	980	0.50	6,149,288	3.15
Wisconsin[4]	3,602,000	43,801	12.15	16,647,019	4.63
TOTALS	68,485,000	189,807	3.17	$252,099,787	3.68

a. Building and Contents loss only.
[1] Fiscal year ended June 30, 1955.
[2] Fiscal year ended June 30, 1954.
[3] Fiscal year ended August 31, 1954.
[4] Insured losses only.
[5] Actual losses where claims were made.
[6] Includes losses in towns and cities only.
[7] No losses less than $50.00.
[8] Fiscal year ended September 30, 1954.
[9] No losses less than $25.00.

Table VI. Estimated Distribution of U. S. Fire Losses by Occupancies, 1954

These estimated figures are intended to show the relative order of magnitude of fire losses by occupancies, and while they are reasonable approximations based on the experience in typical states, they should not be taken as exact records for each class. As explained in the text, 100 per cent has been added in estimating the number of fires, and 33⅓ per cent has been added to the losses to cover unreported losses.

	No. of Fires		Losses	
I. Public Buildings				
Government buildings	1,800		$3,060,000	
Hospitals, institutions	1,700		2,009,000	
Schools and colleges	5,300		24,950,500	
Churches	4,300		17,300,000	
Theatres, including motion pictures	1,800		4,500,000	
Amusement, halls	4,000	18,900	8,438,500	$62,258,000
II. Residential				
Hotels	17,300		10,150,000	
Boarding and rooming houses	8,500		7,707,500	
Apartments	32,000		14,705,000	
Dwellings	450,000	507,800	225,500,000	258,262,500
III. Mercantile				
Offices, banks	10,100		11,756,000	
Restaurants, taverns	23,000		31,937,500	
Miscellaneous mercantiles	42,500		111,723,500	
Warehouses	7,300	82,900	45,576,500	200,993,500
IV. Manufacturing				
Metal workers	2,700		18,975,000	
Woodworkers	4,000		22,649,000	
Grain mills, elevators	3,800		22,366,000	
Food Processing	2,300		4,427,000	
Bakeries	1,200		5,090,000	
Textile workers	6,000		9,507,000	
Printing	1,200		1,957,000	
Laundries	2,100		2,191,000	
Cleaners, tailors	2,000		2,000,000	
Miscellaneous manufacturing	12,900	38,200	65,898,000	155,060,000
V. Miscellaneous				
Barns	39,000		73,290,000	
Outbuildings	27,900		4,270,000	
Lumber and coal yards	2,300		13,612,000	
Piers, including shipyards	2,000		10,750,000	
Railroad property, inc. rolling stock	4,800		10,929,000	
Bulk oil storage, refineries	1,800		15,230,000	
Garages	20,200		26,313,000	
Filling stations	3,700		3,080,000	
Power plants, pump houses	2,800		4,020,000	
Creameries and dairies	2,300		4,830,000	
Miscellaneous structures	20,000	126,800	32,552,000	198,876,000
Total (Building Fires)		774,600		$875,450,000
VI. Other Than Building Fires				
Aircraft	300		70,000,000	
Motor vehicles	161,500		16,100,000	
Forest fires	176,900		44,385,000	
Rubbish, grass, brush	820,000		.....	
Miscellaneous	60,000	1,218,700	10,980,000	141,465,000
Grand Total		1,993,300		$1,016,915,000

Table VII. Estimated U. S. Building Fire Losses by Causes, 1954

These estimated figures are intended to show the relative order of magnitude of fire losses by causes, and while they are reasonable approximations based on the experience in typical states, they should not be taken as exact records for each class.

	No. of Fires	Losses
Chimneys, flues — defective or overheated	33,600	$24,600,000
Sparks on roof	13,900	9,950,000
Defective or overheated heating and cooking equipment —		
Oil-fired equipment	40,300	32,800,000
Gas-fired equipment	6,200	6,750,000
Other and unknown	44,600	42,500,000
Rubbish, ignition unknown	56,600	12,500,000
Combustibles near heaters	12,000	9,900,000
Open lights, flames, sparks	24,600	17,350,000
Hot ashes, coals	14,400	12,040,000
Smoking and matches	121,300	65,400,000
Children and matches	27,100	13,900,000
Electrical, fixed services, fires due to misuse, or faulty wiring, equipment	60,500	77,400,000
Electrical, power consuming appliances	33,600	18,000,000
Flammable liquids, misuse of including vapor explosions, grease, tar, etc.	38,300	34,700,000
Flammable liquid appliances, inc'l. lamps, blow torches, salamanders, etc.	4,400	2,460,000
Torches, welding and cutting	6,000	11,900,000
Gas and appliances, including gas explosions	10,200	13,950,000
Spontaneous ignition	26,900	44,000,000
Lightning	43,200	43,600,000
Thawing pipes	2,000	2,400,000
Sparks from machinery, friction	4,500	8,200,000
Incendiary, suspicious	9,600	25,600,000
Miscellaneous	38,400	20,600,000
Unknown	72,500	268,900,000
Explosions, miscellaneous and unclassified	10,500	23,050,000
Exposure	19,400	33,000,000
TOTALS	774,600	$875,450,000

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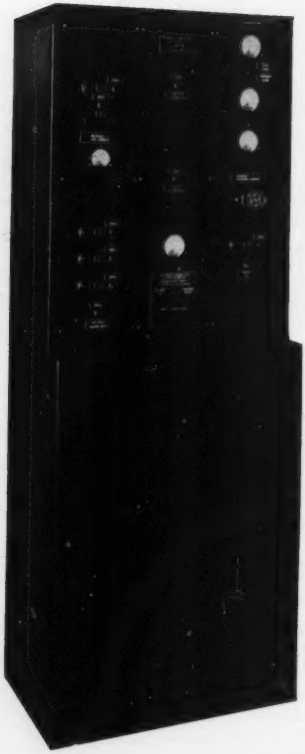

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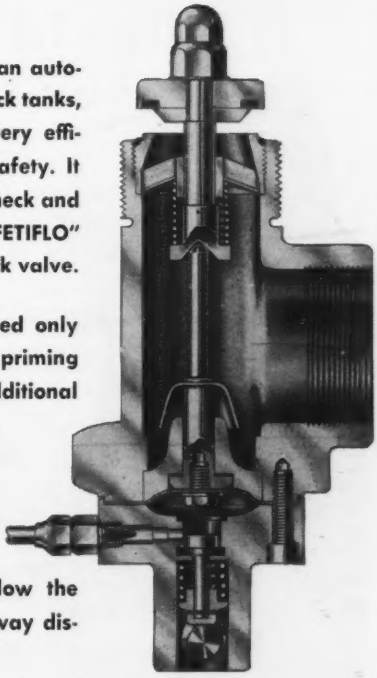

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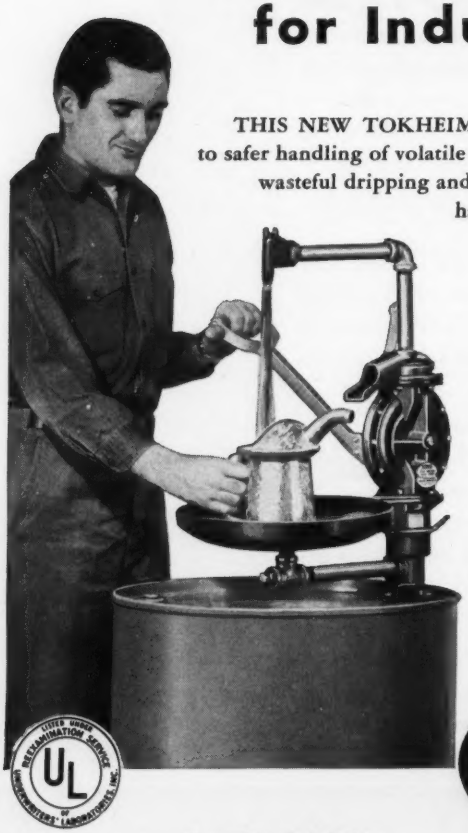

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DESIGNERS AND BUILDERS OF SUPERIOR EQUIPMENT

1686 Wabash Avenue *SINCE 1901* **Fort Wayne 1, Indiana**

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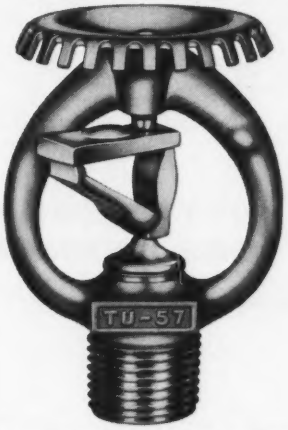


ROCKWOOD WaterFOG SPRINKLER HEAD discharges a uniform pattern of WaterFOG *down into* flame space, bringing the heat absorbing efficiency of WaterFOG to sprinkler systems.

ROCKWOOD TYPE T WaterFOG HEAD used for special hazard fixed piping systems. A variety of fog patterns is available to provide the most efficient protection possible for special hazards.

Two enemies of fire

The Rockwood TU-57 WaterFOG sprinkler gives better distribution of water. It has a wide angle, medium velocity discharge that provides superior fire protection and limits transmission of flammable gases. It is recommended for use in all sprinkler systems.

The Rockwood Type T WaterFOG heads are versatile. By integrating T-Heads into special hazard systems, Rockwood's fire protection engineers can help you solve most any special hazard fire protection problem.

Both the Rockwood TU-57 Head and the T-Head offer positive protection against fires. Each is ideally suited to meet different requirements. Rockwood also makes six different piping systems for FOAM and FogFOAM with a variety of discharge devices. For complete information, send coupon.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . To Cut Fire Losses

ROCKWOOD SPRINKLER COMPANY
1102 Harlow Street, Worcester 5, Massachusetts

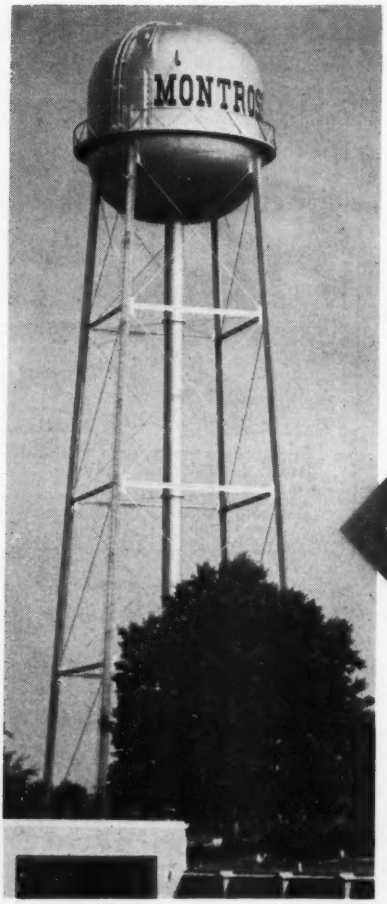
Please send me full information on Rockwood Type T and TU-57 Sprinkler Heads.

Name.....*Title*.....

Company.....

Street.....

City.....*Zone*.....*State*.....



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Elevated Steel Tanks

The Classic
"100 on a 100"

One hundred thousand gallons, on a hundred-foot tower: that's a most frequent Pittsburgh-Des Moines elevated steel tank specification. And the "100 on a 100" provides top value, too—it is a standard product, handsome in appearance because of fine proportions, but without costly frills. Your plant service and fire protection dollar goes a long way with this popular double-ellipsoidal, low head range design. Let us give you the comparative facts, and consult on your water storage requirement.

PITTSBURGH·DES MOINES STEEL CO.
Plants at PITTSBURGH, DES MOINES and SANTA CLARA
Sales Offices at:

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LOS ANGELES (48)	6399 Wilshire Blvd.	SANTA CLARA, CAL.	675 Alviso Road

NOTIFIER AUTOMATION REVOLUTIONIZES

- FIRE DETECTION...
- SPRINKLER SUPERVISION...
- WATCHMAN SERVICE

Here's the NOTIFIER record

1954—Rapid Advancement to the position of a leader in automatic fire detection.

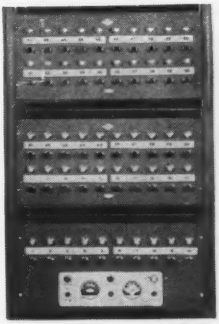
1955—AUTOMATION introduced to the fire detection and sprinkler supervision field.

Human mistakes *eliminated* by immediate detection, notification, and permanent recording of alarms. 100% AUTOMATIC—important NOTIFIER development.

UNBELIEVABLE new developments now under way in our factory.

Safety engineers and plant managers are invited to write for 40-page illustrated booklet on fire detection and sprinkler supervision and maintenance.

Consult our engineering staff on your fire prevention program.



Current UL and FM Listings

Local detection systems
Auxiliary detection systems
Local sprinkler systems
Auxiliary sprinkler systems
Remote (fully supervised) control fire station receiving panel
Automatic code selector
Two or three-wire power supply
Combination relay units
Annunciators
Tripping devices
Manual alarm systems
Notifier thermostats
Vibrating bells

WATCH
Future Issues of The Quarterly for previews of WHAT'S NEW BY NOTIFIER
"The Pace-Setter"

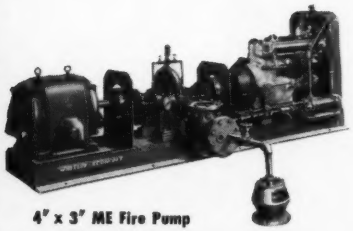
DEALERS WANTED:

Business men, salesmen and fire engineers—a unique opportunity to establish yourself in your community with NOTIFIER.

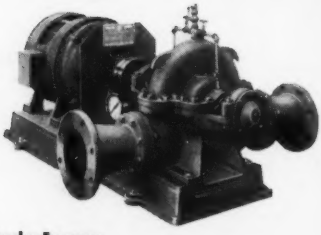
NOTIFIER Automatic FIRE ALARM

NOTIFIER MFG. CO.
239 So. 11th Lincoln, Nebr.

COMPLETE LINE OF PUMPS FOR FULL FIRE PROTECTION



4" x 3" ME Fire Pump with dual drive.



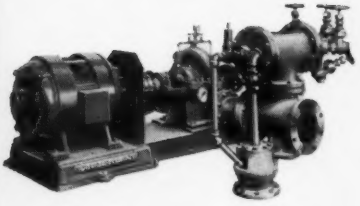
Wheeler-Economy Fire Pump fitted for Booster Service.

WHEELER-ECONOMY FIRE PUMPS

- Centrifugal Fire Pumps
- Centrifugal Booster Pumps
- Tank Filling Pumps

You can recommend Wheeler-Economy Fire Pumps for the needs of all commercial, industrial, public and private buildings.

Years of design, engineering and manufacturing have been devoted by Wheeler-Economy to develop a complete line of approved fire pumps.



Economy Fire Pump complete with Discharge Tee, Hose, Valves, Waste Cone, etc.

Write for Catalog L-154.

WE514

WHEELER-ECONOMY PUMPS

ECONOMY PUMPS, INC., • DIVISION OF C. H. WHEELER MANUFACTURING CO.
19TH AND LEHIGH, PHILADELPHIA 32, PA.

FLAMMABLES OPERATIONS GUIDES

for Prevention of Fires from Unloading and Transferring through to Washing, Cleaning, Swabbing and Disposal

Equipment Selection Guide—a compact, concise illustrated chart containing a selection of various plant operations and the equipment suggested for fire prevention.
Easy to use—Standard 8½" x 11" note book size—Laboratory Approvals indicated.

Catalog of Equipment for Safe Storage, Handling and Use of Flammables—with supplementary sheets illustrating 27 different types of safety and operating containers with sketches showing applications and construction features. Contains a special description and illustration of the Protectoseal perforated metal double-wall fire baffle.

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Venting Fundamentals with Protectoseal Equipment—a new presentation from a functional viewpoint of vapor conservation venting, filling operations, tank car and tank truck loading and unloading, refueling operations—complete with specification data and venting air-flow charts.

Protectoseal provides the ONE complete source of APPROVED Fire Preventive Equipment for ALL Flammables Operations with over 100 specialized containers and devices for protection in every department and every activity all through the plant.

Engineering and Design Service—With the increased use of flammable solvents in production processes, there are undoubtedly some applications for which no special equipment is presently available. In such cases, consult with our sales engineers or contact factory direct. Our engineers and designers are interested in knowing of new applications and we are frequently able to produce new types of safety equipment which fit easily into the process.

PROTECT-YOUR-PLANT
Fill in coupon and attach to company letterhead.
West Coast Warehouse —Los Angeles, Calif. In Canada— Safety Supply Co. Toronto.
A GUIDE TO SELECTION AND USE OF
PROTECTOSEAL EQUIPMENT

THE PROTECTOSEAL COMPANY
1968 So. Western Avenue, Chicago 8, Illinois

Send "A Guide to Selection and Use of Protectoseal Equipment for Safe Storage, Handling and Use of Flammables." Also send the complete catalogs checked below:

☐ Safety Can Catalog ☐ Drum Storage Catalog ☐ Vent and Fitting Catalog containing Venting Fundamentals

Name_____ Title_____

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Address_____

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MECHANICAL JOINT
TAPPING VALVE AND SLEEVE

A. W. W. A.
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FOR EASY, QUICK, PERMANENT INSTALLATION

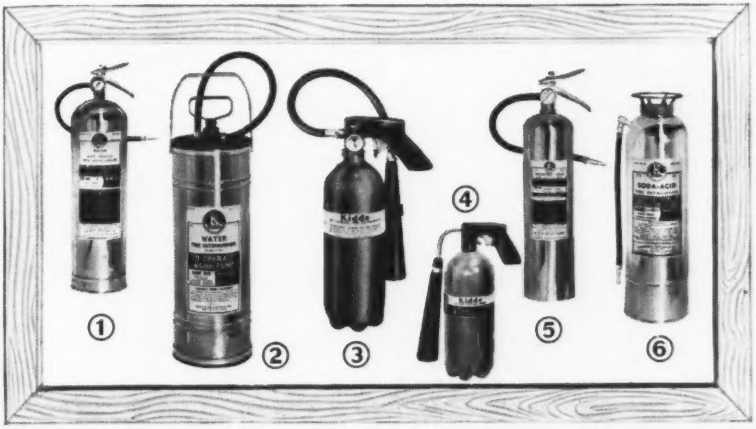
This is our widely used M&H Tapping Valve and Sleeve, with Mechanical Joint connections. The only assembly tool needed is a ratchet wrench. The split sleeve has Mechanical Joint ends, and the longitudinal top and bottom joints are the same type. It may be installed quickly by unskilled workmen. One end of the valve is flanged for bolting onto the sleeve, the other end of the valve is special type Mechanical Joint for connection (first) to the tapping machine and (second) to the mechanical joint pipe line.

Designed for tapping a main under pressure to take off a branch larger than corporation cock size. Valves furnished in accordance with A.W.W.A. specifications, or UA&FM with or without bonnet flange for indicator post, or with rising stem for use in manhole or valve pit. For details, wire or write

M & H VALVE AND FITTINGS COMPANY, ANNISTON, ALABAMA

M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION

NOW! Brand-New Extinguishers Make Kidde Line Most Complete!



Efficient, dependable and superior in design, the new *expanded* line of Kidde extinguishers now makes it easier for you to choose the *right* extinguisher for every fire hazard!

1. Water and anti-freeze. Now available either air-pressurized or cartridge-operated, in either brass or stainless steel, 2½ gallon capacity.

2. Pump tanks. 2½ and 5-gallon sizes, in either galvanized or polished copper tank. Removable all-brass double-action pump throws 40-foot stream.

3. Dry chemical. Air-pressurized in 5 or 10-pound capacities, cartridge-operated in either 20 or 30-pound portables. 150-pound capacity wheeled unit for large hazards.

4. Carbon dioxide. Portables in 2½, 5, 10, 15 and 20-pound capacities, in either trigger or squeeze-grip models. Also wheeled units in single-cylinder capacities of 50, 75 and 100 pounds.

5. Vaporizing liquid. CTC or CBM, pump or air pressure operation with seamless drawn brass shell. Pump capacities 1 to 1½ quarts, pressurized capacities 1 and 1½ quart or 1 gallon.

6. Foam and soda-acid. Seamless drawn brass or stainless steel shell, in 2½ gallon size. Also available: 40-gallon soda-acid and foam wheeled units.

For more information on these and other extinguishers in Kidde's new expanded line, write today for the new Kidde P-8 catalog.

Walter Kidde & Company, Inc.
1051 Main Street, Belleville 9, N. J.
Walter Kidde & Company of Canada, Ltd., Montreal—Toronto

Kidde

The words 'Kidde', 'Lux', 'Lux-O-Matic', 'Fyre-Freez' and the Kidde seal are trademarks of Walter Kidde & Company, Inc.

DO YOU GET THIS KIND OF FOAM

from your AIR FOAM System?

This photomicrograph is the revealing secret of **NICEROL** *AIR FOAM'S TRULY AMAZING heat stability*

SPECIAL TESTING OFFER

Simply write the one word "SAMPLE" on your official stationery and we will send to you ! Freight pre-paid, anywhere in the U.S.A. or Canada, one 5-gallon can of NICEROL Double strength Air Foam Liquid, for $20 C.O.D. (or please enclose check). Test this sample can through your existing foam system—to produce 1,650 gallons of tough foam from only 165 gallons of water, fresh or salt.

The $20 cost of this sample will be deducted from your first order for NICEROL of 100 gallons and over.

THIS IS WHY NICEROL

GIVES GREATER HEAT RESISTANCE

The minute, closely-knit bubbles retain the maximum water content in a foam that is both adhesive and cohesive. This is the reason that Air Foam, made from Nicerol, defies fire breakdown, puts out more fire faster, and definitely outlasts the fire to prevent flashbacks.

NICEROL Air Foam Liquid lasts longer in the can, too, because it is specially processed to prevent corrosion of cans and containers—nor does it form sludge.

NICEROL Air Foam Liquid can be used with all approved types of air foam systems and nozzles.

NICEROL is more widely used throughout the world than any other air foam liquid.

Nicerol

THE LONGER LASTING AIR FOAM

Keeps longer in storage—Puts out more Fire Faster Outlasts the Fire

INQUIRIES INVITED FROM DISTRIBUTORS AS WELL AS USERS. FULL TECHNICAL AND COMMERCIAL DETAILS AVAILABLE FROM

GEORGE T. REYNOLDS & ASSOCIATES, P.O. BOX 395, THORNWOOD, N.Y., U.S.A.

BRITISH FIRE EXTINGUISHERS LTD., 222 SIMCOE ST., TORONTO 2B, ONT., CANADA

VICTAULIC

METHOD OF PIPING

VICTAULIC COUPLINGS

Styles 77, 77-D for standard applications. Simple, fast to install—sturdy and reliable. Sizes ¾" to 30". Style 75 Light-Weight Couplings for light-duty applications. Sizes 2", 3", 4". Additional styles for cast iron, plastic and other pipes. Sizes through 60".

ROUST-A-BOUT COUPLINGS

Style 99 for plain or beveled end pipe. Best engineered, most useful plain end joint on the market. Simple, husky — easy and fast to install. Takes strong bull-dog grip on pipe. Sizes 2" to 8".

VICTAULIC FULL-FLOW FITTINGS

Complete line of Elbows, Tees, Reducers, Laterals, etc. — to fit all Victaulic Couplings. Streamlined for top efficiency, easy to install. Sizes ¾" to 12".

VIC-GROOVER TOOLS

Handy, on-the-job grooving tools that do the job in half the time. Light weight, easy to handle — operate manually or from any power drive. Automatic groove position and depth. Sizes ¾" to 8".

APPROVED BY:

Factory Mutual

New York City Board of Standards and Appeals, Cal. #413-53-SM.

Underwriters' Laboratories, Inc.

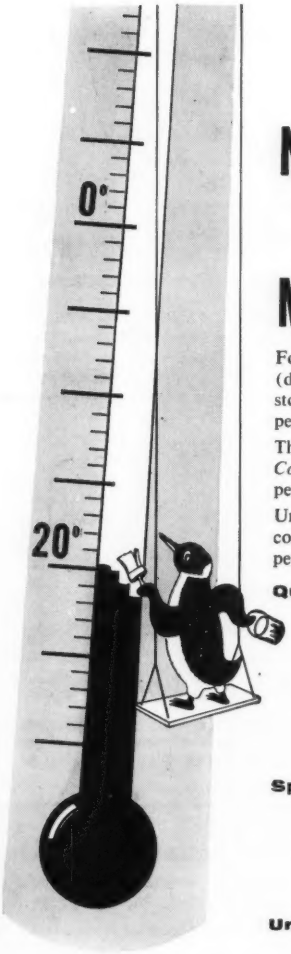
Proven for 26 years **on both wet and dry Fire Protection Systems. Standard with most major sprinkler companies for bulk-run and cut-in piping. Victaulic Couplings are installed in *less than one-half the time* required for other standard pipe joints.**

THE EASIEST WAY TO MAKE ENDS MEET

VICTAULIC

COMPANY OF AMERICA

P.O. Box 509, Elizabeth, N. J.



important advance in year-round fire protection

NEW 3% AER-O-FOAM LIQUID MAINTAINS MOBILITY AT –20°F

For control of fires in flammable liquids, 3% foam liquids (double strength) offer obvious advantages: economy of storage space, facility in transport and handling, low cost per unit volume of foam.

The new, patented National *AER-O-FOAM Liquid, 3% Cold Foam,* combines these advantages with the ability to perform as well at sub-zero temperatures as at summer heat.

Unique in its field, this new AER-O-FOAM Liquid assures correct proportioning in the foam-making process at temperatures as low as –20°F. The extra protection is apparent.

Quick facts on performance

National AER-O-FOAM Liquid, 3% Cold Foam, is equally effective with soft, hard, or sea water.

It stores easily for longer periods because there is no deterioration under normal storage conditions.

It is compatible with almost all 3% regular liquids.

It meets all applicable requirements of U. S. Government specifications.

Special Cold-Weather AER-O-FOAM Trucks

For use with 3% Cold Foam Liquid, National Foam offers special foam trucks insulated for operation in very low temperatures. Carrying up to 750 gallons of 3% Cold Foam Liquid, the trucks can produce as much as 12,000 gallons of foam per minute.

Unlimited supply

As a result of recent expansion in National Foam's production facilities, the new 3% Cold Foam Liquid is available in unlimited quantities. Full details will be forwarded promptly on request.

NATIONAL FOAM SYSTEM, Inc.
West Chester, Pa.

DETECT-A-FIRE®

Rate Compensation Actuated THERMOSTATS insure positive Fire Detection for alarm or release systems

Fenwal DETECT-A-FIRE units are based on an entirely new principle. The outer shell is the sensing element — reacting to the temperature of the air around it. The contacts function when surrounding air reaches a danger level.

- *Hermetic Sealing* of internal electrical components.
- *Stainless Steel Construction* — for corrosion resistance and long life.
- *Temperature Setting Range*, 140 F to 725 F.
- *Long Spacing* . . . 25 feet . . . economy of installation.
- *Repeatable.* Unit re-sets itself, nothing to replace.
- *Shock and Vibration Resistant* . . . rugged construction.

SERIES 70 HORIZONTAL MODEL.

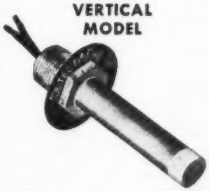
For locations where appearance is a factor. Suitable for all commercial, industrial, mercantile and public buildings, institutions and ships, in locations classified as "ordinary" under the National Electric Code.

TYPES 7020 and 7021

Flush Mounting Unit for new construction and concealed wiring. Type 7020, normally closed circuits; Type 7021, normally open circuits. Designed to fit standard 4" junction boxes. For exposed wiring, Types 7020-1 and 7021-1 with surface adapter ring.

LISTING and APPROVALS: Ⓤ, ◈, USCG, and American Bureau of Shipping Acceptance.

SERIES 71 VERTICAL MODEL



For ordinary and hazardous locations i.e., Class I, Groups C and D; Class II, Groups E, F, and G. Explosion-proof in itself. For hazardous locations, mount to Crouse Hinds CPS 021 Cover or Appleton BFGS Hub Cover for explosion-proof system.

TYPES 7120 and 7121

For concealed and exposed wiring. Type 7120, normally closed circuits. Type 7121, normally open circuits.

LISTING and APPROVALS: Ⓤ, ◈, and American Bureau of Shipping Acceptance.

SEND FOR THESE BULLETINS.

They give the latest authoritative data on fire or overheat detection. They discuss in full the rate compensation principle; give exact engineering data. Write for Bulletins MC-107A and MC-108 to Fenwal Incorporated, 1410 Pleasant Street, Ashland, Mass.

Fenwal

DETECT-A-FIRE® Thermostats

DYNAMIC, RATE COMPENSATION ACTUATED FIRE DETECTORS

Ansul Dry Chemical Piped Systems Now U.L. Approved For Industry-wide Use

For the first time, Automatic Dry Chemical fire protection for class B and C hazards

The science of fire protection took a big step forward when Ansul's *Dry Chemical Piped System* was approved by Underwriters' Laboratories. Eight years of development and field application made this important approval possible.

Ansul's Dry Chemical Piped Systems provide instant, around-the-clock protection for such hazards as paint dip tanks, spray booths, generators, flammable liquid pumping stations, exhaust ducts—wherever there is a hard to reach or highly flammable stationary installation.

Automatic or manual systems, or a combination of both, are available. Also, by using automatic selector valves, one piped system can protect two or more separate hazards.

Protecting a hazard with an Ansul Dry Chemical Piped System will, in most cases, result in increased insurance savings. Protect your business, safeguard your investment, get in touch with your Ansul Man today.

LISTED UNDER REEXAMINATION SERVICE
UL
UNDERWRITERS' LABORATORIES, INC. OF

Call the Ansul Man!

Get in touch with your local Ansul man through the "yellow pages" or write ANSUL CHEMICAL COMPANY, Fire Equipment Division, Dept. F-24, Marinette, Wisconsin. *Write Ansul for your copy of new Fire Equipment Catalog.*

ANSUL

GLOBE
SAVEALL
SPRINKLER

PRODUCT OF THE CHEMICAL AGE

UPRIGHT

PENDENT

For nearly fifty years Globe has designed, manufactured and installed all types of fire protection equipments including wet and dry pipe sprinkler systems, deluge systems and special hazard systems involving fog, foam and CO_2. Write for free copy of "How to Detect and Stop Fire Automatically."

Manufactured and Installed By

GLOBE AUTOMATIC SPRINKLER COMPANY

PHILADELPHIA, PA.

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Nation Wide
Central Station Protection Services

Sprinkler Valve Alarm — Complete Sprinkler Supervisory — Manual Fire Alarm — Automatic Fire Alarm — Temperature Alarm — Oil Burner Supervision — Burglar Alarm — Hold-Up Alarm — Vault & Safe Protection

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Smith Detective Agency & Nightwatch Service, Inc.

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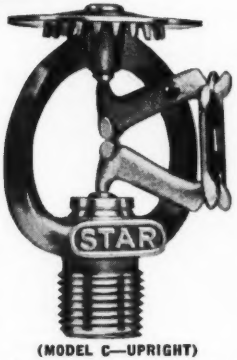
The AMAZING New

Star Spray Sprinkler!



(MODEL C—UPRIGHT)

With its

Unequalled Performance

Gives You . . . . . .

SUPERIOR PROTECTION — revolutionary in method — for any type of occupancy — no matter how severe the hazard . . . . . with **LESS WATER USED** — more effectively and more efficiently — for total extinguishment and cooling. . . . All water discharged goes directly on the fire — not on the ceiling. . . . Ceilings are so cooled that no sprinkler will open unnecessarily. . . . . **STAR SPRAY SPRINKLERS** — the ultimate in modern fire protection — can replace former-type sprinklers without changes in piping. . . . . Available for installation in either **UPRIGHT** or **PENDENT** position.

Approved by Factory Mutual Laboratories
Listed by Underwriters' Laboratories, Inc.

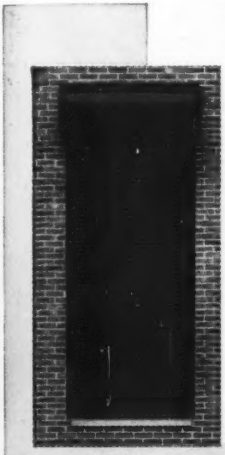
Write for name and address of STAR licensed contractor nearest your location, to:

STAR SPRINKLER CORP.

Westmoreland and Collins Sts. — Philadelphia 34, Pa.

Licensees in all Principal Cities of the United States and Canada

Automatic Rolling Steel
FIRE DOORS *and* WINDOW SHUTTERS
PREVENT SPREAD *of* FIRE!



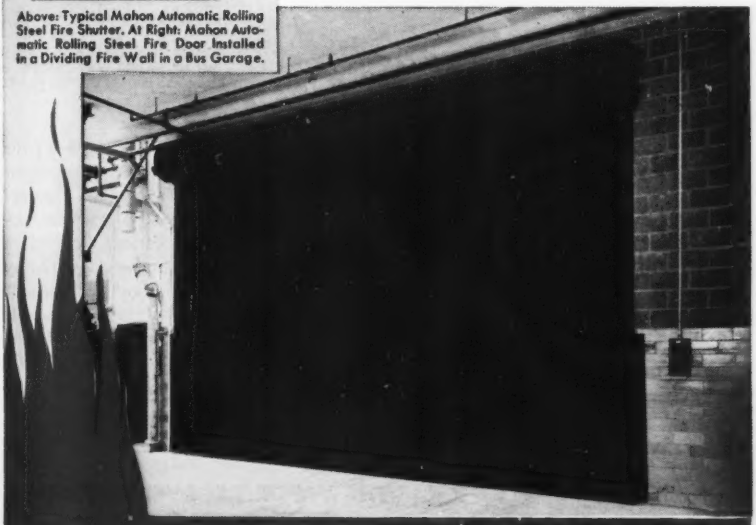
You need good automatic fire doors in fire walls, corridors, and vertical shafts . . . in some cases automatic rolling steel window shutters are necessary to protect your building and its contents from fires which may originate in nearby buildings. Many, many cases are on file which confirm that timely action of automatic rolling steel fire doors and window shutters have confined a fire to its point of origin and permitted its being extinguished with comparatively small damage. Make a survey of your building now, and don't delay action. You will find a Mahon Automatic Rolling Steel Fire Door or Window Shutter to meet each of your requirements—all bear the Underwriters' Label. These automatic fire doors may be operated manually or mechanically in every day use. If a fire should break out while they are in the open position, the automatic mechanism will close the door, cutting off drafts and preventing the spread of the fire. See Sweet's Files for complete information, or write for Catalog G-55.

THE R. C. MAHON COMPANY

Detroit 34, Michigan • Chicago 4, Illinois

Manufacturers of Automatic Rolling Steel Fire Doors and Window Shutters. Also Many Types of Standard General Service Rolling Steel Doors and Grilles, Insulated Metal Walls, and Steel Deck for Roofs, Floors and Partitions.

Above: Typical Mahon Automatic Rolling Steel Fire Shutter. At Right: Mahon Automatic Rolling Steel Fire Door Installed in a Dividing Fire Wall in a Bus Garage.

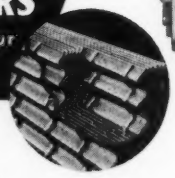


MAHON ROLLING STEEL FIRE DOORS and WINDOW SHUTTERS

LOW COST
FIRE & EXPLOSION PROTECTION

for FLAMMABLE LIQUID STORAGE

WITH "Varec"
FLAME ARRESTERS
in combination with your
VENT VALVES



Flame Arrester Unit listed by UNDERWRITERS' LABORATORIES Approved by Associated Factory Mutuals Laboratories and other governing agencies.

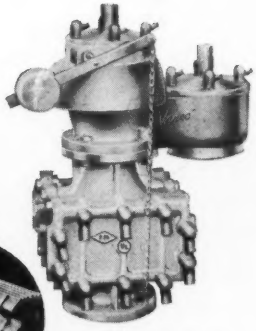


Fig. No. 5800A Conservation Vent Unit consisting of VAREC Vent VALVE in combination with VAREC FLAME ARRESTER

You can rely on VAREC CONSERVATION VENT UNITS to provide full fire protection on your liquid storage at low cost. Protection against entry of flame through the venting device is certain when Varec Flame Arresters used. Protection against excessive pressure or vacuum is assured by the VAREC VENT VALVE. The combination unit gives you complete security against major hazards of flammable liquid storage. Average installation costs 1/10th of 1% of your investment in tank and products. Secure full details from your VAREC Representative or write factory.

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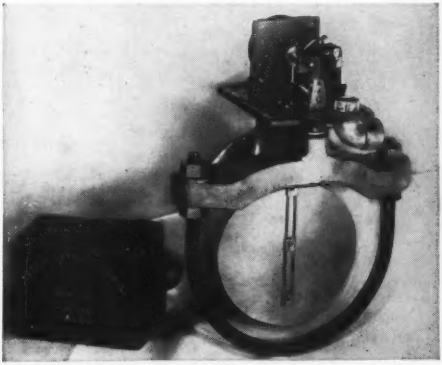

5-inch size shown above. To install simply drill 2-inch hole in pipe.

Model PRS-1
Sprinkler
Waterflow Alarm

This device is approved by Factory Mutual Laboratories and Underwriters' Laboratories, Inc.

- This device is also made as Model PRT-1, a coded waterflow transmitter.

- Also made in explosion proof models.
- Made in all sizes from 2½" to 8".
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- Has enclosed electrical contacts for 15 amp. 125 volts, A.C. and ½ AMP, 125 volts, D.C.

Size is 1⅝" x ⅝"

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Fire Detector

Underwriters' Laboratories, Inc. Approved.

- Self restoring and can be heat tested.
- Electrical contacts are silver or gold and are enclosed.
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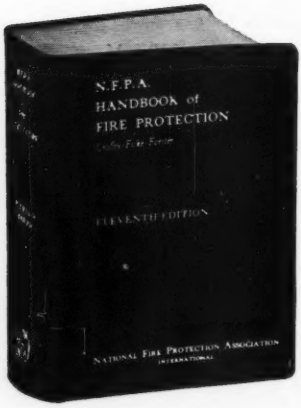

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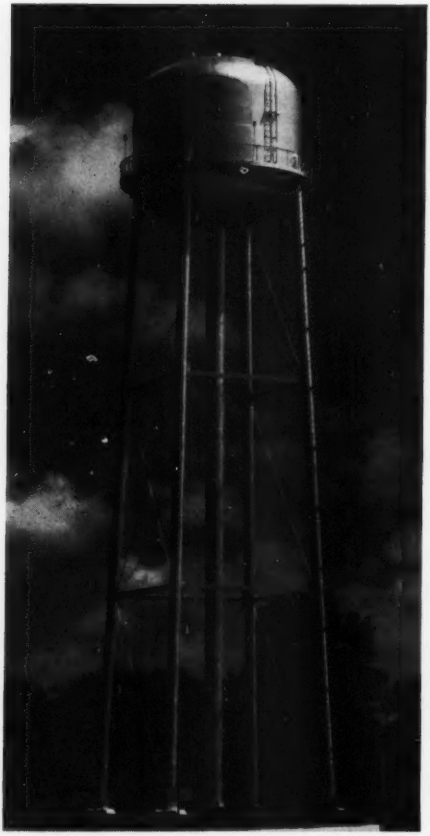

The 100,000-gallon Ellipsoidal bottom elevated tank shown on the left was installed at the Underwriters' Laboratories Testing Plant in Northbrook, Illinois. The tank, 100-ft. to the bottom, is used as the primary water supply for their sprinkler system.

Underwriters' Laboratories, Inc., established in 1894 as a non-profit organization operates laboratories for the examination and testing of devices, systems, and materials. The Northbrook laboratories consist of four buildings containing a total of 46,000 square feet. Except for the pump house and fire station, the 388 sprinkler heads protect the entire plant.

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The opportunity for you to benefit from fire prevention activities is continuous, too. They can be a constant source of new contacts, community good will and recognition. And, by reducing fire losses, they help hold down the cost of fire insurance.

Fire prevention is our business. Fire fieldmen of our Companies are trained to help eliminate the hazards of fire in homes — schools and churches — in business. They are ready to assist you in your fire prevention problems before you build, or on the elimination of hazards in existing buildings. They may be contacted through local insurance agents, and there is no charge for this service.

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The C-O-TWO Pre-Detector System has been subjected to extensive testing and carries Underwriters' Laboratories, Inc. listing, as well as Factory Mutual Laboratories approval. Proven pilot installations have been made in such diversified properties as a television station, an electric power company network analyzer room, a railroad signal tower, an airline flight training equipment room and the offices of an insurance company.

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Report on **TRUSSTEEL*** Stud and **ROCKLATH*** Plaster Base Partition Assembly

ONE-HOUR FIRE RATING

This non-load bearing partition assembly, a product of U.S.G. research, consists of TRUSSTEEL Studs, ROCKLATH Plaster Base with TRUSS-LOK Clip Attachment, and plaster. Finishes to overall wall thickness of 4½", 5¼", 6" and 8", depending on the stud size.

In tests at nationally recognized laboratories, the partition qualified for a one-hour fire rating, and an excellent sound transmission rating of 48 decibels was obtained.

In addition, the ease of concealing pipes, conduits and air ducts within the finished wall results in substantial savings in time and labor costs. Reductions as high as 10% in plumbing and electrical estimates—made possible by the "hollow stud" assembly—have been reported.

Versatility, light weight and strength are further advantages of this partition assembly. For further information, consult your local U.S.G. Architects' Service Representative.

SEE PACIFIC COAST BUILDING OFFICIALS CONFERENCE RESEARCH RECOMMENDATION REPORT NO. 486, DATED JANUARY 7, 1955.

TECHNICAL DATA

TRUSSTEEL Studs in 2½", 3¼", 4" and 6" sizes provide thickness to meet job requirements.

This partition assembly weighs approximately 10 lbs. per square foot when plastered with perlite aggregate plaster, and approximately 15 lbs. per square foot with sand aggregate plaster in any TRUSSTEEL Stud width.

Tests in the U.S.G. structural laboratory show that the partition compares favorably in strength with wood or other metal stud construction used for similar purposes.

*T.M. REG. U.S. PAT. OFF.

The partition system is limited to the use of ⅜" plain or perforated ROCKLATH on studs spaced 16" on centers.

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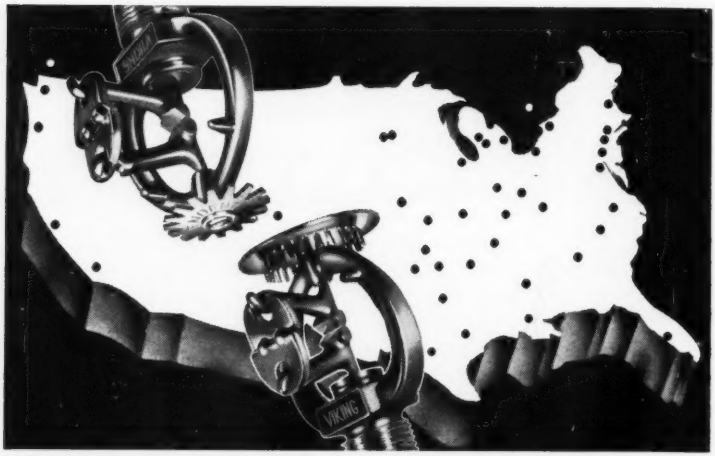

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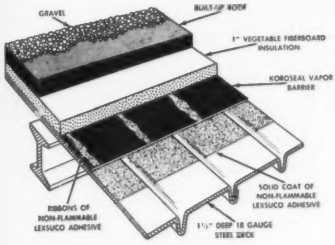
Factory Mutual fire test proves superior fire safety of Lexsuco Roof Construction



Lexsuco Roof Vapor Barrier and Securement Construction

The Lexsuco Construction (at left) was recently subjected to a large scale fire test at Factory Mutual Laboratories in Norwood, (Mass.) with a steel deck on a building 100' x 20' fired for 30 minutes with gasoline burned to produce the A.S.T.M. time temperature curve.

This test proves conclusively that the Koroseal* Vapor Barrier and non-flammable Lexsuco Adhesive: (1) makes no contribution to fire spread within a building and even when used with combustible vegetable fiberboard insulation does not result in extensive fire spread beyond the zone of direct exposure; (2) does not produce dense black smoke which hampers efficient fire fighting.

Pertinent findings from this and other factory Mutual fire tests: (1) Bituminous materials contribute to fire spread and are undesirable between roof deck and insulation. (2) Combustible gases liberated from asphaltic materials spread fire because pressures developed force them through deck joints and their ignition produces a chain reaction of fire under the deck. (3) Built-up roofing surfaces above insulation contribute in no way to spread of occupancy fires until roof deck collapses. (4) Where the Lexsuco Constructions described in the Factory Mutual Laboratory Report are used without any combustible elements in the building structure, the need for automatic sprinkler protection is determined by the building contents.

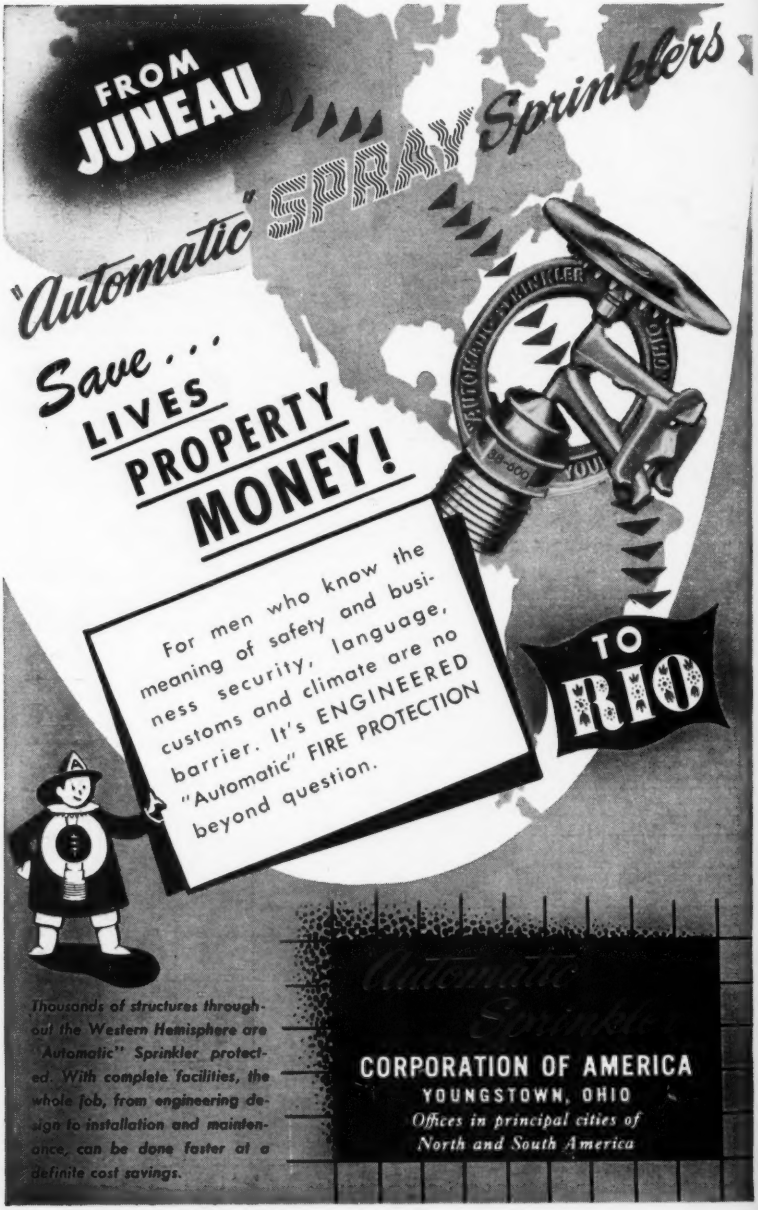
*T. M. B. F. Goodrich

Type of Construction Over 18 Gauge Steel Deck and Under Built-Up Roof Surface	Flame Spread Beyond Exposure Bay Under Steel Deck (Duration of Test—30 Min.)		Visibility Within Building During Test		Asphalt Drippage	Percent of Insulation Consumed	
	% Of Structure	Time In Minutes to Reach Flue End	% Obscured By Black Smoke	Time In Minutes		Fire End	Flue End
2 Ply Mopped Asphalt Vapor Barrier with 1" Vegetable Fiberboard Insulation Secured with Asphalt	100	10.5	100	8	Some	67	67
1" Vegetable Fiberboard Insulation Strip Mopped to Deck With Asphalt	100	12.8	100	7	Some	63	50
Heavy Felt Vapor Barrier Secured By Asphalt Cement With 1" Glass Fiber Insulation Secured With Asphalt	100	12.8	100	7¼	None	50% Of Glass Fiber Insulation Blackened	50% Of Glass Fiber Insulation Blackened
1" Vegetable Fiberboard Insulation Mechanically Fastened to Deck	68	—	0 Burners Visible During Test	—	None	63	6
Lexsuco Koroseal Vapor Barrier and 1" Vegetable Fiberboard Insulation Secured with Non-Flammable Lexsuco Adhesive	46	—	0 Burners Visible During Test	—	None	50	0

Results of Lexsuco test compared with other Factory Mutual fire tests conducted under sponsorship of Metal Roof Deck Technical Institute. Identical procedures, control measures, and recording methods were used in all of these tests.

For a complete Factory Mutual Laboratories Test Report on the Lexsuco Construction, write . . .

LEXSUCO INC.
4817 Lexington Ave., Cleveland 3, O.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AUTOMATIC FIRE ALARMS AUTOMATICALLY KEEP SMALL FIRES SMALL

First when seconds count!

Fire strikes and spreads so rapidly that any delay — even seconds — in notifying the Municipal Fire Department can be disastrous . . . might put you out of business permanently.

You can depend on a Gamewell Fire Alarm System to contact the Municipal Fire Department *immediately* and *automatically* when a sprinkler head goes off or an alarm box is pulled . . . no guesswork . . . no costly delays!

Easily added to your present sprinkler system, a Gamewell Fire Alarm System safeguards your personnel, your plant and your production. Get *complete* protection . . . write NOW for the name of your nearest representative.

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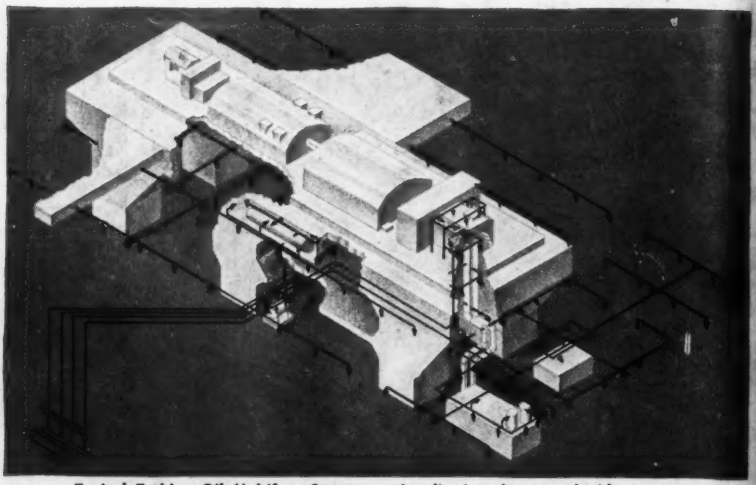
Complete Fire Protection for Turbine Oil Systems



Typical Turbine Oil Mulsifyre System, sectionalized and actuated either automatically or by remote manual control

The severity of turbine oil fires of recent years, and the heavy losses resulting from them, have proved the need for an efficient protection system throughout the *whole* area of hazard. One of the most practical extinguishing agents for oil fires is water spray — and, one of the most effective methods of producing water spray is a Grinnell Mulsifyre System.

Grinnell Mulsifyre attacks oil fires in these different ways:

- By forming a fire-extinguishing blanket of emulsion on the surface of the oil.
- By introducing water vapor molecules between the oil vapor and oxygen molecules, to make the mixture unburnable through "vapor dilution".
- By cooling oil at its surface, thus slowing down production of burnable vapor.
- By using up heat through flash evaporation of water, to keep oil vapor below the ignition point.

Grinnell manufactures and installs fire protection systems for every normal or special fire hazard — Grinnell Automatic Sprinkler Systems for standard risks; Grinnell Mulsifyre, ProtectoSpray, Multitrol Deluge, ProtectoFoam, C-O-Two, and dry chemical systems for special or extra-hazardous risks. Write for your free copy of "Occupancy Fire Record in Electric Generating Stations" and "Turbine Oil Fire Protection". Grinnell Company, Inc., 274 West Exchange St., Providence, R. I. Branch Offices in principal cities.

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EMULSION EXTINGUISHMENT OF OIL FIRES